final report

Project Code: A.TEC.0104

Prepared by: Philip Green
Greenleaf Enterprises Pty Ltd

Date published: December 2014
PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Lamb chining technology comparison – Final Report

This is an MLA Donor Company funded project.

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Executive Summary

Removal of lamb chine bones has been manual, requiring significant bandsaw work which has implications on product yield and consistency of finished product specification as well as OH&S risks. Automated removal of chine bones was identified by industry in conjunction with MLA and AMPC as an opportunity to improve efficiency and product value in Australian lamb operations. Chine removal systems in various forms have been tested in the industry in the past but with varying success until recently. The general process of automated chine removal is summarised here in Figure 1.

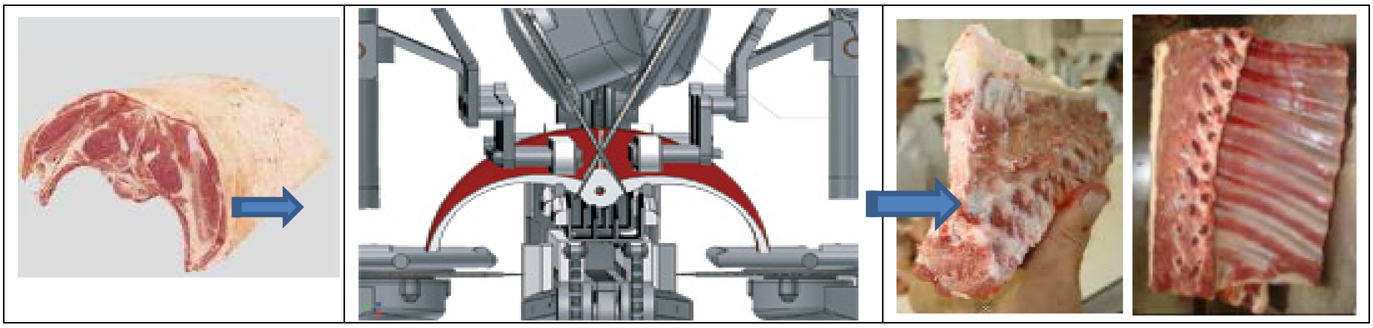


Figure 1: General process of removing chine and feather bones from a bone-in rack saddle

MLA and AMPC have funded research and development of two different technologies to automate the chine bone removal process and to address a range of industry needs. In that time alternative solutions have been developed independently including two systems from New Zealand. At least four chine removal technologies have recently been developed in this area supplied by different providers and with different approaches and trade-offs. These systems replace the manual bandsaw method, providing labour savings and yield improvements among other benefits and are summarised in Table 1. Although the review focuses on chine de-boning a number of systems have other functionality.

Table 1: Technology summary

Attribute	ATTEC	BLM	Macpro	Scott
Racks/min	12+	7	10 plus	12+
Working Footprint m^2	$10m^2$	$4m^2$	$4m^2$	$4m^2$
Chined rack yield increase over manual ($/head)	$1.93*	$1.92	$2.33	$2.29
Flap removal	✓	×	Prototype	× (LEAP IV)
Loin de-boning	×	×	✓	×
Able to fully automate	×	×	×	✓ (LEAP IV)
Capital Cost	315,000	220,000	335,000	285,000
Payback	2.21	2.52	2.12	1.74

**Figure estimated – Knife ready specification tested at $0.90/head*

Benefits of automated lamb chining

A range of benefits are provided over manual bandsaw operation and are detailed in Table 2 but the biggest financial benefit is yield with some labour saving as summarised in Figure 2. Although the reduction in OH&S costs is not large, the ability to remove operators from bandsaws on what is quite a dangerous job is worth a lot more in increased safety.

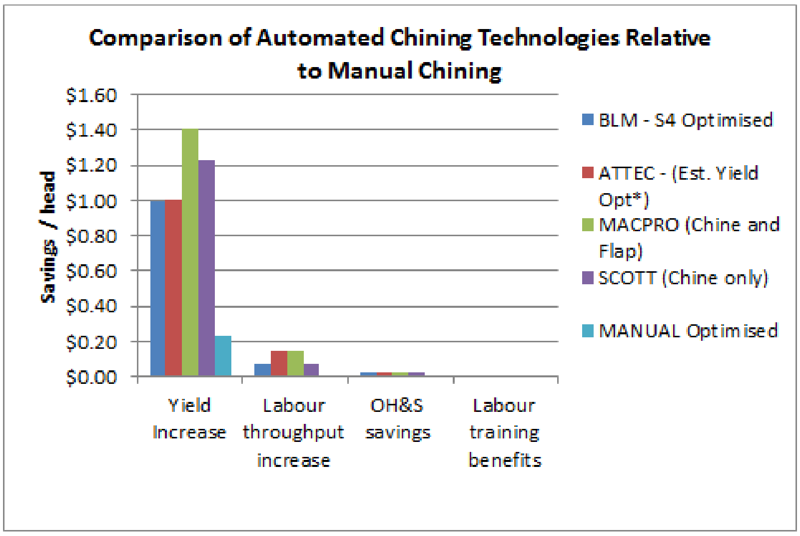


Figure 2: Summary of benefits across all chining methods

The Table 2 takes into account all the value benefits and trade-off in costs to summarise net benefit on a per head basis at the bottom for each system.

Table 2: Cost benefit analysis of each system

Useful working life			10		15		10		10		10	
COBOTIC EQUIPMENT*												
* Each method compared back to Manual Bandsaw												
	lanual Benchma		MANUAL Optimise		BLM - S4 Optimised		TEC - (Est. Yield Op		SCOTT (Chine only)		CPRO (Chine and Fl	
Benefit summary	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit
Yield Increase			$0.23	$211,751	$1.00	$916,276	$1.00	$922,208	$1.22	$1,126,525	$1.41	$1,296,503
Labour throughput increase			$0.00	$0	$0.07	$67,600	$0.15	$135,200	$0.07	$67,600	$0.15	$135,200
OH&S savings			$0.00	$0	$0.02	$20,000	$0.02	$20,000	$0.02	$20,000	$0.02	$20,000
Labour training benefits			$0.00	$0	$0.00	$394	$0.00	$806	$0.00	$403	$0.00	$826
$ Benefit			**$0.23**	**$211,751**	**$1.09**	**$1,004,269**	**$1.17**	**$1,078,215**	**$1.32**	**$1,214,528**	**$1.58**	**$1,452,529**
Capital cost			$0.01	$12,000	$0.02	$14,667	$0.03	$31,500	$0.03	$28,500	$0.04	$33,500
Maintenance Cost			$0.00	$0	$0.00	$712	$0.00	$712	$0.00	$712	$0.00	$712
Operational Cost			$0.02	$22,260	-$0.02	-$18,616	-$0.02	-$19,137	-$0.02	-$17,476	-$0.02	-$19,155
Risk of mechanical failure			$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0
Risk of mechanical injury			$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0
Risk of product damage			$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0
Total cost			$0.04	$34,260	$0.00	-$3,237	$0.01	$13,076	$0.01	$11,736	$0.02	$15,058
Total net $ benefit			$0.19	$177,491	$1.10	$1,007,506	$1.16	$1,065,139	$1.31	$1,202,792	$1.56	$1,437,471

System return on investment

The system return on investment calculates how quickly the net benefit per head will recover the total capital cost, based on the number of systems required to achieve a throughput of 3,650 per 8 hour shift (460/hour). Note the slower time to pay back the BLM system is due to requiring two systems for the volume.

Table 3: Summary performance measures based on consistent volume across all systems

	Manual Benchmark	MANUAL Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and Flap)
Capital cost	$60,000	$120,000	$220,000	$315,000	$285,000	$335,000
Number of systems *(see Cell C27)*		2	1	1	1	1
Gross return Per head		$0.23	$1.09	$1.17	$1.32	$1.58
Total costs Per head		$0.04	$0.00	$0.01	$0.01	$0.02
Net Benefit Per head		$0.19	$1.10	$1.16	$1.31	$1.56
Annual Net Benefit / unit		$88,746	$1,007,506	$1,065,139	$1,202,792	$1,437,471
Annual Net Benefit		$177,491	$1,007,506	$1,065,139	$1,202,792	$1,437,471
Pay back (months)		8.11	2.62	3.55	2.84	2.80
NPV		$1,126,625	$8,956,280	$7,166,090	$8,162,909	$9,761,196

Alternative modelling assumed each system would operate at its maximum capacity resulting in different volume for each scenario as shown in Table 4. In smaller plants the BLM system provides a more comparable return on investment where one systems capacity is better matched to plant throughput.

Table 4: ROI based on each system operating at its own maximum throughput

	Manual Benchmark	MANUAL Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and Flap)
Capital cost	$60,000	$60,000	$220,000	$315,000	$285,000	$335,000
Number of systems *(see Cell C27)*		1	1	1	1	1
Gross return Per head		-$0.04	$1.09	$1.20	$1.37	$1.59
Total costs Per head		$0.01	$0.00	$0.01	$0.01	$0.01
Net Benefit Per head		-$0.05	$1.09	$1.19	$1.37	$1.58
Annual Net Benefit / unit		-$22,921	$1,047,344	$1,713,787	$1,966,924	$1,895,759
Annual Net Benefit		($22,921)	$1,047,344	$1,713,787	$1,966,924	$1,895,759
Pay back (months)		-31.41	2.52	2.21	1.74	2.12
NPV		($220,988)	$9,319,121	$11,721,923	$13,529,850	$12,980,020

Contents

1 Introduction

Removal of lamb chine bones has been manual, requiring significant bandsaw work which has implications on product yield and consistency of finished product specification as well as OH&S risks. Automated removal of chine bones was identified by industry in conjunction with MLA and AMPC as an opportunity to improve efficiency and product value in Australian lamb operations. Chine removal systems in various forms have been tested in the industry in the past but with varying success until recently. The general process of automated chine removal is summarised here in Figure 3.

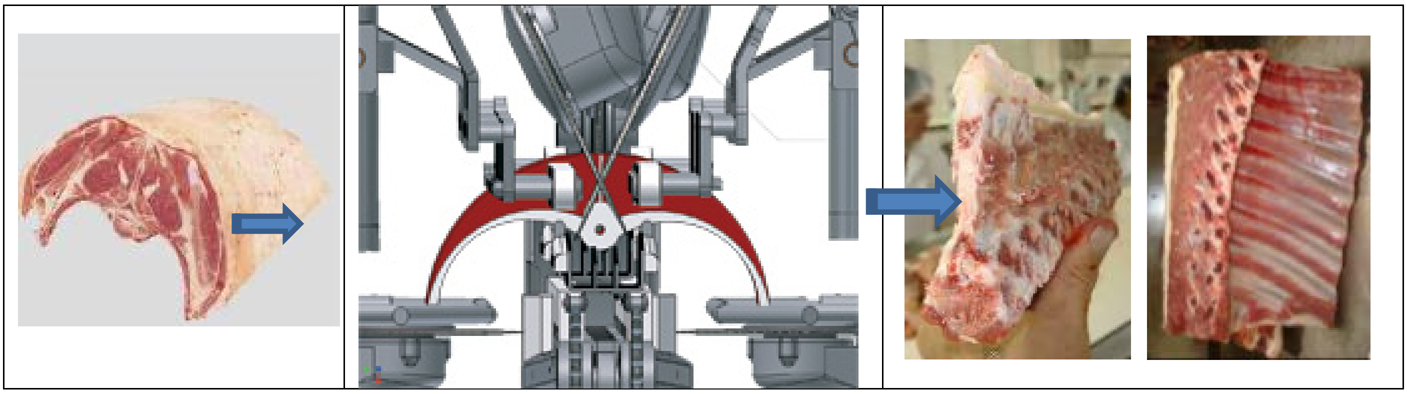


Figure 3: General process of removing chine and feather bones from a bone-in rack saddle

MLA and AMPC have funded research and development of two different technologies to automate the chine bone removal process and to address a range of industry needs. In that time alternative solutions have been developed independently including two systems from New Zealand. At least four chine removal technologies have recently been developed in this area supplied by different providers and with different approaches and trade-offs. These systems replace the manual bandsaw method, providing labour savings and yield improvements among other benefits.

ATTEC, a European manufacturer, has developed a system that removes chine bone and flaps but requires a larger footprint. **BLM** have developed a standalone chining system which is the most widely used system in the Australian industry but is also the oldest technology. **MACPRO** in NZ has developed the "exos" stand-alone chining that is also available as a multifunction system that switches between chine bone removal and short-loin de-boning in less than 3 seconds. **Scott Technology** have developed a chine removal system that can either be installed as a standalone system like the others mentioned above, or as an integration with the Scott Leap IV middle cutting solution. This last solution provides a range of additional labour saving alternatives to the others but comes at a price. Some companies remove chine bones manually which requires a lot of bandsaw work and are considering which of the range of solutions are best for their particular businesses. MLA and AMPC are being asked to provide recommendations to industry on the pros and cons of the different systems. In order to do this a comparative study of the different systems was undertaken with the results being the basis of this report.

2 Objectives

The objectives of this work were to:

1. Benchmark the existing manual method used for chine bone removal in Australia and quantify the value opportunity that exists for automation (Considering benefits realised by the automated systems);
2. Quantify the differences between carcase specifications and finished product specifications for the different Australian processors;
3. Conduct yield trials at a range of lamb processors where the systems are installed to enable detailed equipment performance comparisons;
4. With the understanding in 2) above, determine impact on Australian requirements;
5. Review each of the equipment solutions providing a list of observations and considerations for small and large plants.
6. Development of an Excel based CBA model to support the written observations and comparisons between the systems.

3 Technology Description

This section provides a brief background to the four different automated technologies and a summary in Table 5. Note that although the review focuses on chine de-boning a number of systems have other functionality. This should be taken into account when considering line speeds, labour and yield improvements and capital cost. More detailed analysis of specific system attributes are discussed in later sections.

Table 5: Technology summary

Attribute	ATTEC	BLM	Macpro	Scott
Racks/min	12+	9	10 plus	12+
Footprint m^2	$10m^2$	$2.5m^2$	$2.5m^2$	$2.5m^2$
Chined rack yield increase over manual ($/head)	$1.93*	$1.92	$2.33	$2.29
Flap removal	✓	×	Prototype	× (LEAP IV)
Loin de-boning	×	×	✓	×
Able to fully automate	×	×	×	✓ (LEAP IV)

**Figure estimated – Knife ready specification tested at $0.90/head*

The BLM system has been commercially available for a number of years with more than 17 installations in Australia and 26 in New Zealand. The other 3 systems (manufactured by ATTEC, Macpro and Scott Technology) have only become available in the past 12-18 months with 4 installations across the 3 systems at the time this review was conducted. Each system differs in design with a range of advantages and disadvantages depending on the plant layout and customer requirements.

3.1 BLM chining machine

The BLM chining machine requires one operator to manually load and manually unload the machine. The system claims to process up to 9 racks per minute but was observed at closer to 7 during trials. Operation of the cutting mechanism includes 2 rotary blades cutting on the underside of the rack and a stationary knife system that separates the longissimus muscle from the spinous process of the vertebrae.

Figure 4: BLM Machine at Westside Meat

3.2 ATTEC chining machine

The ATTEC chining machine requires one operator to manually load the system but unload is automatic. The system can run at over 12 racks per minute and is governed completely by how fast an operator can manually load flap on racks onto the transfer conveyor. The cutting mechanism includes a static knife set the rack is pushed through to separate loins from the vertebrae. A set of circular knife blades cut ribs from the chine bone which generate less sawdust or yield loss than manual bandsaw operation. Flaps are removed by a second set of rotary knife blades at 1 of 3 pre-set distances by the operator.

Figure 5: ATTEC chining system footprint with in-feed conveyor on the right

3.3 exos MACPRO system

The system is mounted on wheels to enable relatively easy movement in and out of position. The system can be configured as a multifunctional unit including both a chining and a loin deboning module but variants are available for either chine removal or loin saddle boning only. As a multifunctional machine production rate is approximately 3 carcases per minute or 9-10 short loins per minute and 10+ racks per minute when processing single products. One operator manually loads the machine but unloading is automatic. The small footprint is achievable as the machine is designed to discharge direct to an existing product conveyor.

Figure 6: exos MACPRO Machine at JBS

3.4 Scott's Chinning Machine

The Scott's chining machine is available either as a standalone unit requiring one operator to load the system with automatic unload, or as a fully automatic module within Scott's larger LEAP IV middle processing machine which processes full saddles automatically and delivers to slicer ready products. The cutting mechanism is unique as it also includes circular knife blades on the top cuts which scrape down the feather bone to separate the loin muscle.

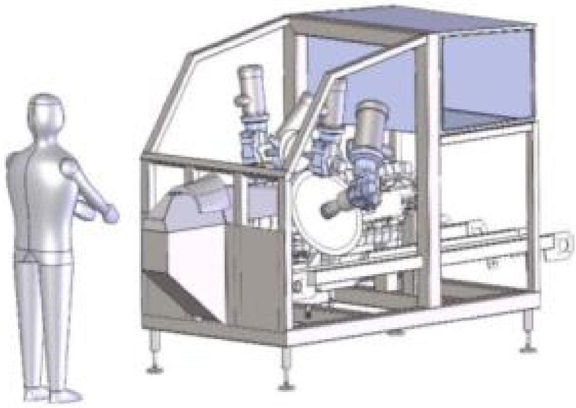
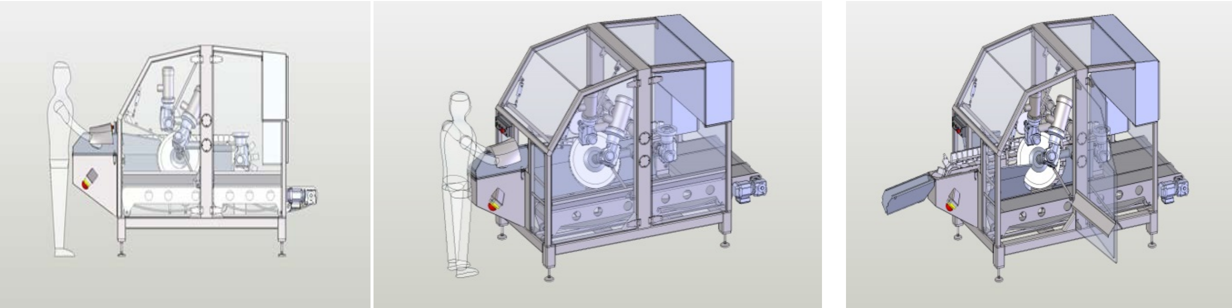


Figure 7: Scott's Chining Machine



3.5 Manual chining

Manual chining involves bandsaw operator splitting a rack, then removing the chine bone from each half with two additional bandsaw cuts. The process is quite dangerous and also produces a wide range in yield depending on operator as demonstrated by optimum performance in Figure 8 and less than optimum bandsaw accuracy resulting in poor retail presentation of chine on retail chops in Figure 9. During trials the difference in yield performance between optimised and commercial boning yields was measured and demonstrated the wide variation in manual yields across manual operators.

Figure 8: Manual chining result

Figure 9: Manual bandsaw preparation of retail chops shows variation in manual accuracy

4 Methodology

Preliminary scoping of manual processes and one automated system was conducted prior to site visits and data collection to understand the processes, variables and costs and benefits to be addressed during the site visits and comparison between the technologies. The four technologies ranged from well-established systems through to new equipment with only one or two commercial trial installations. The site trials and locations are different for each system because of this. The following areas were addressed during the trials:

- Optimum equipment performance – during the scoping stage it was noted that daily maintenance, sharpening of blades and other equipment settings are often not optimised. This means a comparison between different pieces of equipment may not give an accurate indication of the equipment's performance. We wanted to ensure that each machine is running at its optimum performance before doing trials and as such, some equipment providers had a technician on site prior to the trials to check the systems operation.
- Another aspect of the trials was to test variation or impact of maintenance on equipment performance where possible. This gave an indication on the drop in performance where a system may be maintained at less than optimum levels and indicates the importance of daily maintenance to equipment performance.
- Return on investment is a key driver for many companies. Yield of saleable chined racks out of the boning room is the most significant driver of value so collection of yield performance data formed a large portion of this work. A standard method for measuring yield and operational performance was developed below.
- Some customer specifications such as retail knife ready racks limit the extent that yield can be maximised. An assumption was made that all systems would be focusing on maximum yield for export specifications. However, during the last trial the ATTEC equipment was optimised for a domestic retail knife ready specification which also produces a lower yield of saleable rack. The amount of chine bone removed from the rack on the bottom cuts was greater than for all other system trials. Impact of cuts separating the loin from featherbones was not affected. To enable easier comparison between systems an estimate of yield performance for export specifications on the ATTEC machine has been projected based on cutting mechanisms and similarities with other cutting systems.

4.1 Site inspection trials

The Table 6 below summarises the locations of each of the systems tested during the review.

Table 6: Process Plant, location and equipment to review

Equipment	Process Plant	Location
Manual process	**JBS** **Frewstawell**	Bordertown, SA Stawell, Vic
BLM Engineering	**Westside Meats** **Silverstream** **ALC**	Bacchus Marsh, VIC Dunedin, NZ Brooklyn, Vic
ATTEC	**Frewstawell**	Stawell, Vic
Macpro exos	**Lean Meats** **JBS**	Oamaru, NZ Longford, Tas
Scott Technology	**Silverstream** **JBS**	Dunedin, NZ Bordertown, SA

4.2 Yield Data Collection and Calculations

The review of manual chining was across three days of production and included comparison in performance over the period. Data was analysed and assembled to allow comparison with results from other equipment trials.

Scrape testing with a sharp boning knife to remove all remaining meat from the loin side of the chine bone was used to measure this yield difference. Left and right sides of racks and yield loss from each side were weighed separately to measure consistency of each machine in cutting down the centre line without skewing to the left or right. Refer to Figure 36 and Figure 37.

Figure 10: Scraping remaining loin from chine and weighing for each side of the chine bone enabled comparison between systems

Figure 11: Racks from a chinning system – note the increased amount of M. multifidous meat remaining between the loin and the chine bone

Cutting lines were compared for each system with resultant yield and finished product quality reported. Ability to remove the ribs closer to the chine bone and with a neater cut plays a large part in delivering higher yields of bone-in racks.

5 Results and Discussion

This section describes the technology capabilities and processing requirements that should be considered by a processor when selecting the most suitable machine for their operation. The capabilities included in this section are summarised and compared between technologies in detail in Table 18 on page 38.

5.1 Machine footprint

Most boning rooms have limited space for new processes so equipment footprint and product flow in and out of a machine needs to fit into existing process flows. In some cases where equipment significantly improves the flow of the whole boning room or reduces multiple units of labour, plants are more willing to adjust operations to accommodate the equipment.

They range in size from 3.2-10m^2 with the ATTEC machine being the longest system which is due in part to its in-feed conveyor loading system which is adjustable on a plant by plant basis.

5.2 Loading Mechanism

All systems are manually loaded although Scott Technology have a fully automated version as a component of their LEAP IV middle machine. In all manual systems the operator has to pick up a rack from the previous process and correctly orient and centre it on the loading mechanism. The systems all have slightly different designs and involves:

- Centring of the rack to ensure even separation of the loin on both sides of the feather bone; and
- Triggering the system to engage the rack;
- Each system then guides the rack through the cutting process unassisted.

All systems reviewed save 1 to 2 labour units depending on room processing speed.

The chinning process for the BLM and ATTEC machines is initiated by pressing of a button in Figure 12 and Figure 14. The Macpro machine in Figure 15 is activated by closing the safety door. The Scott system continuously moves the drive chain as the rack is loaded onto it. All systems automatically eject the rack, chine bone (and flap in the case of ATTEC) onto the same exit chute except the BLM machine. The BLM ejects the waste chine bone out a side chute but the chined racks are manually removed by the operator as shown in right of Figure 14.

Figure 12: Manual loading of rack onto loading conveyor with laser centring guide. Manual button above rack indexes chain forward when pressed. Roller holds rack in position.

Figure 13: Exit conveyor automatically removes product

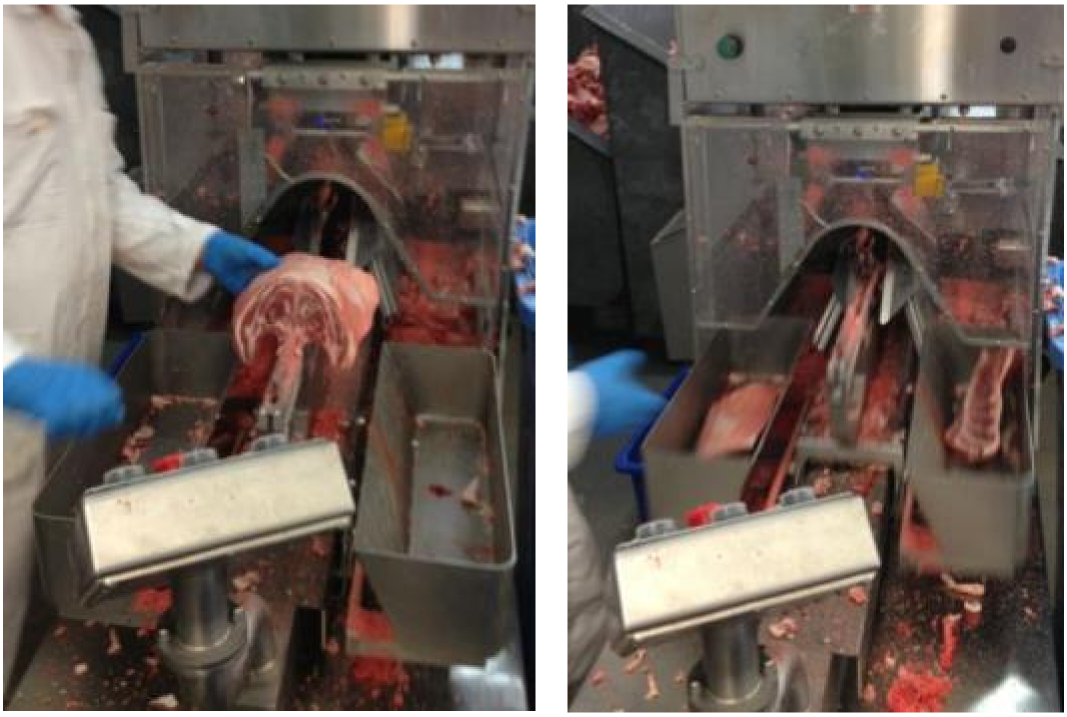


Figure 14: Carriage enters chinning saws after operator positions rack and presses button on console. Carriage retracts with chinned racks in trays. Operator removes racks to belt or table.

Figure 15: Operator loads rack in chamber. As door is closed holding mechanism grasps rack then pushes rack through knife and saws. Chine bone and racks exit machine onto belt or table

5.3 Lamb Chine bone anatomy

The anatomical structure of lamb rack vertebrae change from carcase to carcase and from the cranial to the caudal ends of the rack. In particular the articular process protruding from the vertebrae into the loin muscle shown in Figure 16 has an impact on the amount of meat that can be removed from the chine bone while maintaining separation of the ribs.

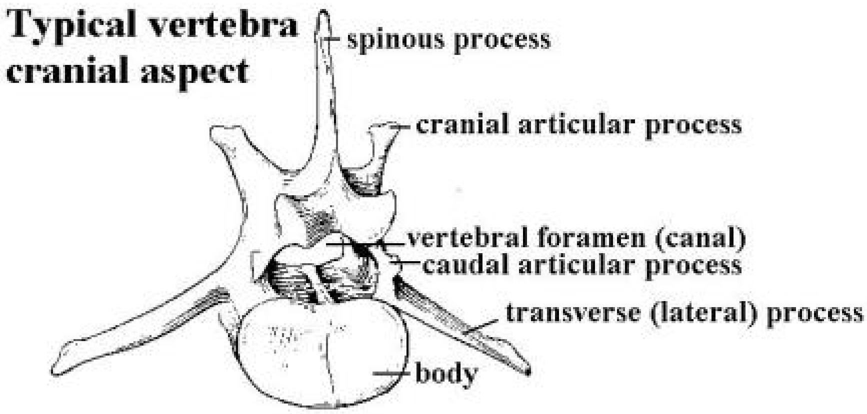


Figure 16: Skeletal anatomy of a lamb chine bone

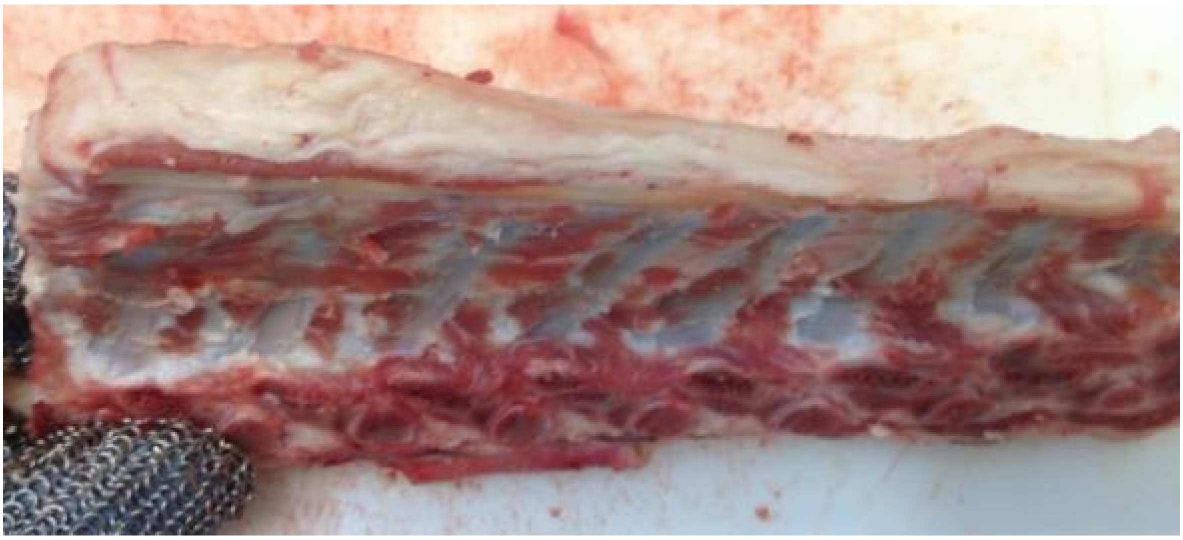


Figure 17: Ridge of articular process from Figure 16 after scraping off remaining loin muscle

Figure 17 shows the ridge of the articular process. The saw cut removing the rib bones from the vertebrae where the mesh glove is holding the chine bone in the figure cannot be cut any closer to the vertebra if knife separation is required on the finished rack. Figure 18 demonstrates a chining method where the pocket of loin muscle above the ridge of the articular process has been completely removed while Figure 19 is a poor example where quite a bit of loin still remains on the chine bone.

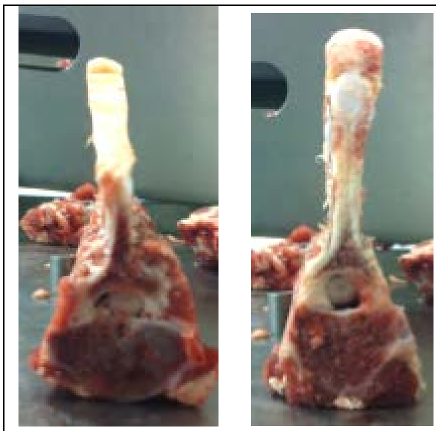


Figure 18: High yield chine removal

Figure 19: Low yield chine removal

The saw configuration used to remove the chine bones and the ability to adjust the angle of those blades will impact on a chinning systems ability to meet customer specifications while maximising yield for carcase size. Ideally the process of separating the loin from the vertebra and the process of cutting the ribs off the rack are two separate processes as shown in Figure 20. Independent adjustment of these cuts gives the greatest flexibility to a chining machine in managing yield and customer specification for all carcases.

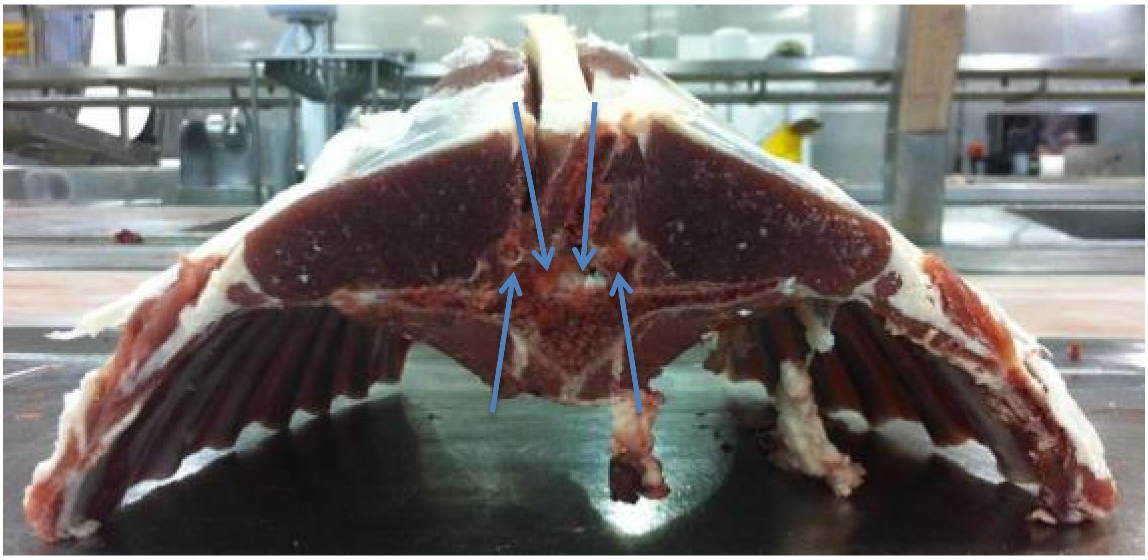


Figure 20: Four cuts removing chine bone from rack

5.4 Impact of chine cutting mechanism design on yield

The range of carcase types, customer specifications and product runs change in all processing plants. Manual processes, although adaptable, have inherent variation. Chining machines should reduce variation over manual processes for similar carcase types on the same customer specification. The ability for systems to adapt as these variables change impacts throughput and ability to meet customer specifications and yield targets. As carcase size and customer specifications change the ability to adapt quickly starts to differentiate the various machines available.

Management of yield is an important aspect of installing an automated Chining machine. Automated systems improve consistency of yield over manual operation. But how much a chining machine can improve yield over manual operations depends on the design configuration and adjustability of the cutting mechanism. It is also important that the adjustments on the Chining machine allow customisation of the cutting technique for different customer specifications and carcase types. This can have a big impact on plant yields.

System designs are outlined in this section relative to the anatomical considerations covered earlier. The ability to adjust the cutting technology settings is an additional consideration which is discussed after this design section.

Some customer specifications require full separation of ribs from the vertebrae as in the dotted cutting line in in Figure 21 and in the area marked ❷ in Figure 22 while other customers may accept partial separation of the ribs as in the solid cutting line in Figure 21 where there is no separation of the rib and vertebrae. Adjustment of the bottom cutting blades impacts on degree of separation. The amount of bone chip left on the rack is also influenced by the angle and width of the cut shown by the circle in the right of Figure 21.

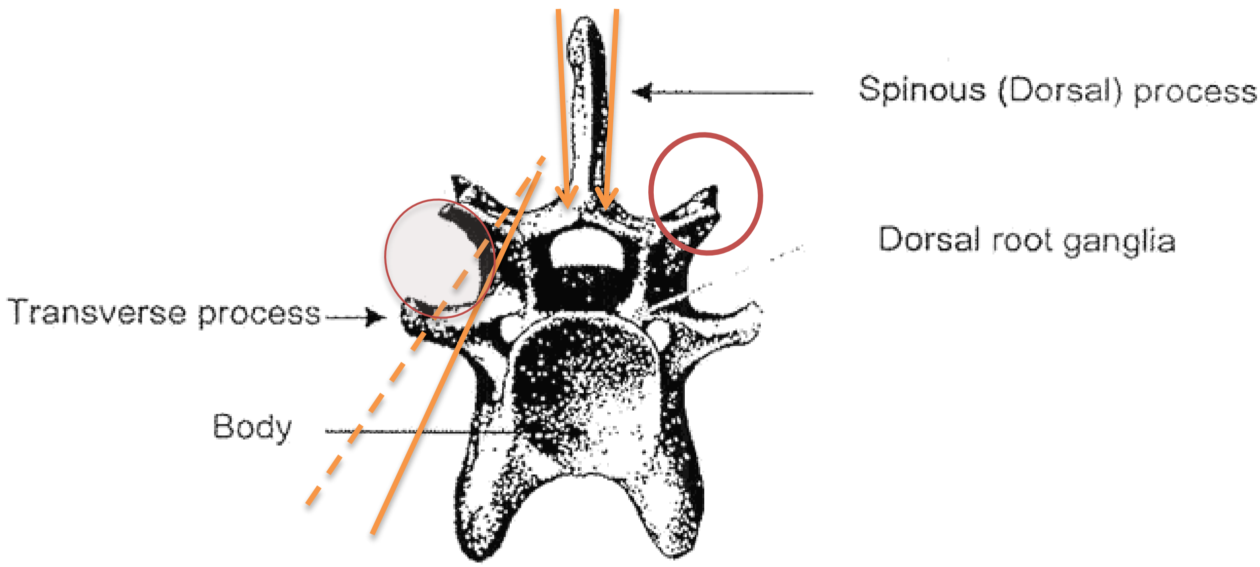


Figure 21: Change in angle of cut gives greater separation between ribs for knife portioning (Left) and minimises amount of bone chips left on the rack (right). Knife cut down onto featherbones.

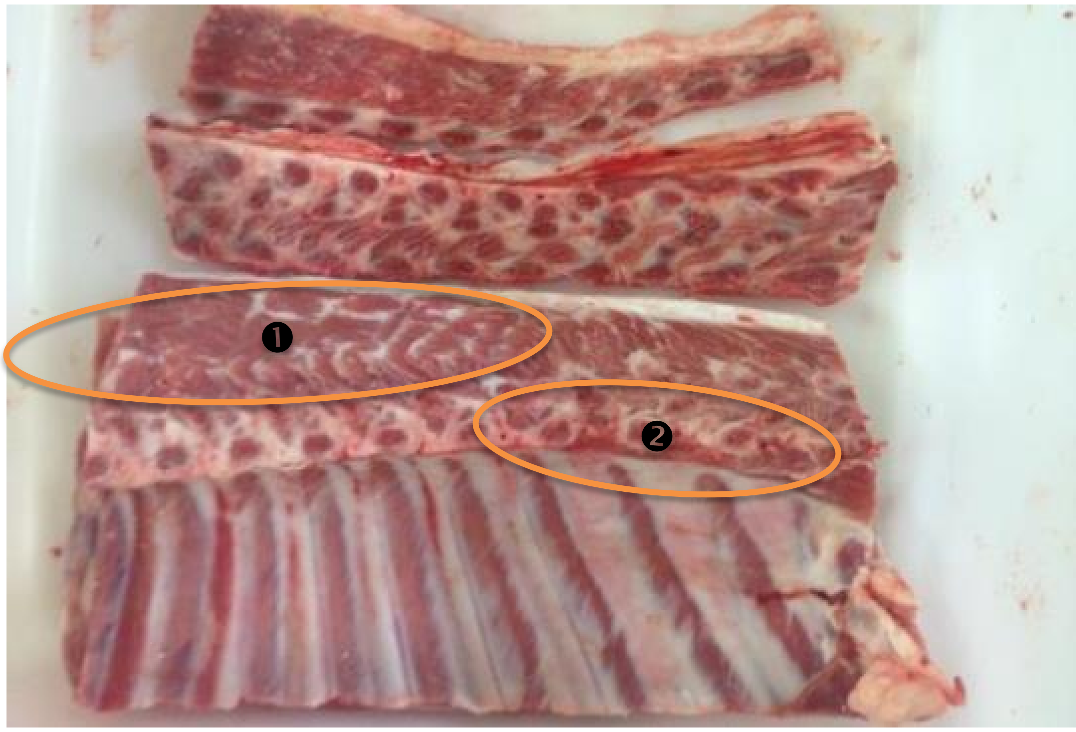


Figure 22: Degree of separation of ribs from vertebrae will impact on yield. Example of very clean chine bone removal on manual bandsaw with almost no cutting in M.Multifidous

When removing the chine bone from the rack it is important in maximising yield to remove as little of the multifidous muscle shown in ❶ in Figure 22 as possible. This is impacted by the top cutting mechanism on the chining systems.

The scrape test trials conducted on site remove any remaining muscle from the chine bone and measure how well the chining technologies clean the chine bones. If the cutting technology is too variable or cuts into the M. multifidous too much it will begin to cut into the M.longissimus muscle as shown in Figure 23 which further reduces yield.

Figure 23: Removal of chine bone has just started to cut into the loin muscle

5.5 System cutting mechanisms

The ability for plants to maximise yield is quite significant and depends on machine cutting configuration described in the previous section. Some of the adjustments possible with the machines include the angle to saw blades from the vertical plane along with adjustment of the distance between the two saw blades allowing the blade to cut closer or further from the spinous process of the vertebrae and is the subject of this section.

Machines that are adjustable but require stops and input from maintenance team tend not to be adjusted. These machines tend to operate on one setting for all situations as it gets too difficult to stop and change. Machines an operator can change with real-time adjustments at a push of a button are more likely to be adjusted to maximise performance and consistency.

This section describes the type of adjustment settings observed during the machine comparison. Adjustment to the cutting of the ribs and the removal of loin from the featherbones or spinous process are the two areas impacting on yield and are summarised in the first two sections of Table 7.

Table 7: System cutting adjustment comparison

Adjustment		ATTEC	BLM	Macpro	Scott
Cutting ribs from vertebrae					
Rib saw angle	Inline	×	×	×	×
	Offline (O)	×	×	✓	×
	Offline (M)	✓	✓	✓	✓
Rib saw width	Inline	×	×	✓	×
	Offline (O)	×	×	✓	×
	Offline (M)	✓	✓	✓	✓
Separating loin from spinous process					
Push blade width	Offline (O)	×	2 settings	AUTO	N/A
	Offline (M)	×	×	AUTO*	N/A
Push blade floating	Offline (M)	✓	N/A	✓	N/A
Rotary knife	Offline (M)	N/A	N/A	N/A	✓
Flap removal					
Flap removal	Inline	✓	N/A	?	× (LEAP IV)
	Offline (M)	✓	N/A	?	× (LEAP IV)

*Rib saw angle not adjustable in-line. Separating tissue from Spinoue process: Width between blades self-adjusting in-line to suit bone dimensions ✓ Has capability × Don't have capability

5.5.1 BLM cutting configuration

Operation of the cutting mechanism includes 2 rotary blades cutting on the underside of the rack and a stationary knife system that separates the longissimus muscle from the spinous process of the vertebrae.

Figure 24: Blades cut either side of spinous process include a stepped gap

Figure 25: Demonstrates the way the chine bone passes between the blades while separating from the loin muscle on the rack. The stepped gap allows the thicker tip of the vertebrae to fit through while still cutting close to the narrow portion of the spinous process

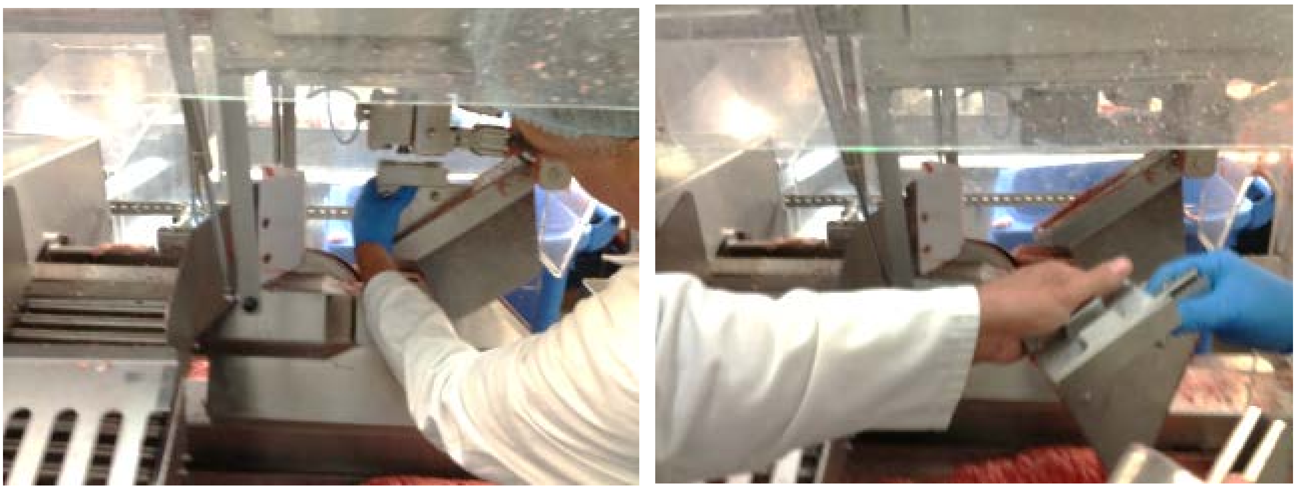


Figure 26: Removal of the blade mechanism for sharpening and adjustment is an easy quick release process

5.5.2 Attec cutting configuration

As the saddle enters the machine on the transfer belt it is pushed through two fixed blades shown in ❶ of Figure 27 that cut on either side of the feather bone. A stabilising roller holds the rack in position as it passes through this first cut process and is shown in the right of the figure. The blade configuration and shape is similar to the BLM method in Figure 24 and Figure 25 and has minimal if any adjustability.

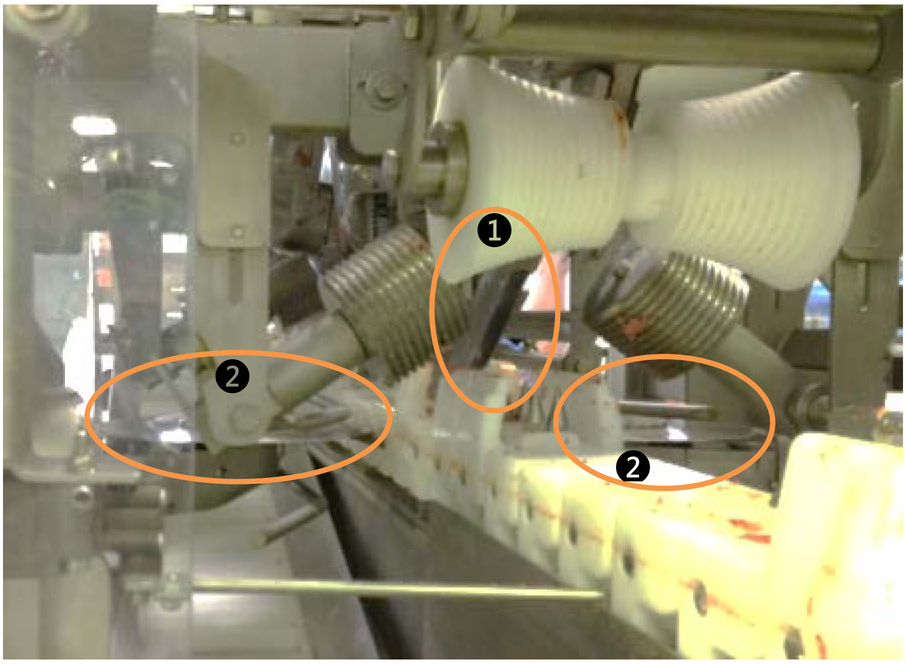


Figure 27: Featherbone separation blade ❶. Flap removal saw on either side of conveyor cut adjustable flap lengths ❷.

The chine bone cutting mechanism uses two circular blades consecutively (Figure 28) and offset from each other at an angle either side of vertical as shown in Figure 29 to cut through the bones. The circular blades generate less sawdust and reduce variation in yield loss compared to manual bandsaw operations.

Figure 28: Two circular knife blades offset from each other cut through either side of the chine bone

Figure 29: Two saw blades cut alternately across the vertical plane of the chine bone and through the ribs. Horizontal blades on either side remove bone-in flaps

Adjustment of flap removal lengths during production to meet customer requirements is made using the digital display which switches between three pre-configured settings. Changes to flap length can be made in real time and don't slow production or require maintenance to be involved. Adjustment to chine removal cut angle is simple for maintenance personnel to make and only takes about 5 minutes between production runs.

5.5.3 Macpro cutting configuration

Adjustment to the angle of the cut removing the ribs from the vertebrae changes the amount of separation of the ribs from the vertebrae to suit different customer specifications. This also impacts on amount of bone remaining on the chined racks. If desired, provision is made that the mammillary processes are excluded from the product.

Adjustment to the cut separating the loin from the featherbone changes the weight of loin meat remaining on the chine bones. This cut does not impact on knife separation where the bottom and top cuts are independently adjustable as in Figure 20 and Figure 21.

Figure 30: Macpro saw and knife cutting combination

Figure 31: Macpro knife mechanism separates muscle from vertebrae above ribs, followed by saw removing rib as a second cut in the foreground of Figure 30

Because the blade system is "floating" the system is self-adjusting for each bone set by following key parts of the bone geometry.

5.5.3.1 Macpro Bottom saw Blade settings

The Macpro machine is the only system with the ability to adjust cutting settings at normal production speeds without stopping production. The adjustment changes the start position of the bottom blades that cut through the ribs shown in Figure 33. The result is removal of more of the bone, influencing rack yield and amount of knife separation between the bones. This on-the-fly adjustments for LARGE and SMALL racks adjustment is made using one of the levers in Figure 32 while the other two are for "machine reset" and Long/Short LOIN.

Figure 32: Pre-set adjustments controlled by the operator in real-time

The adjustment for cutting angle is set at optimum for client specification requirements on commissioning but simple adjustment using a series of turnbuckles in Figure 34 allow almost too much flexibility of adjustment to angles.

Figure 33: Adjustment to cutting width and angle as in Figure 21

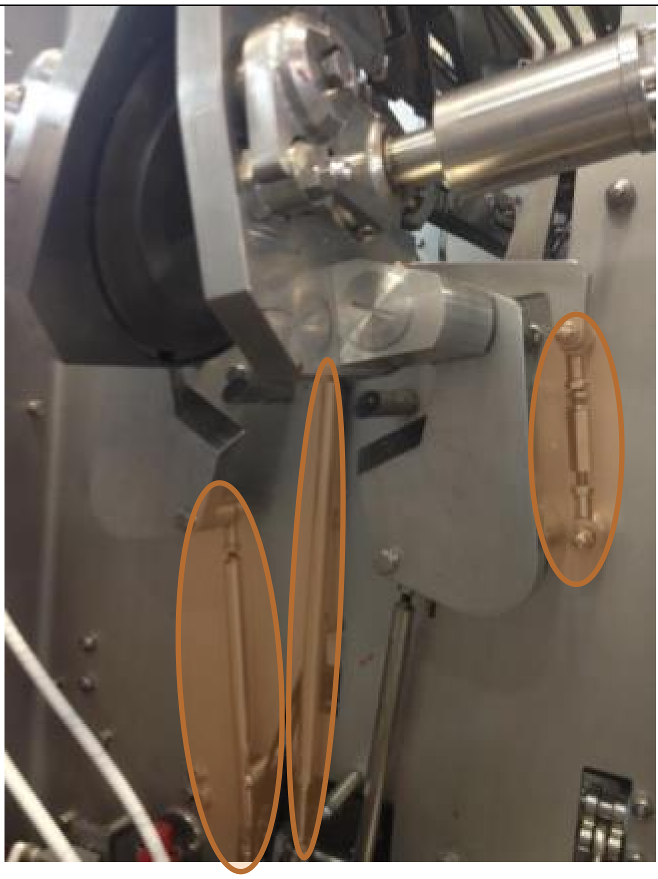


Figure 34: Turnbuckle adjustments allow easy fine tuning of system pre-sets by maintenance

5.5.4 Scott cutting configuration

The Scott's cutting system uses a similar saw configuration as the Macpro and BLM systems to cut up through the ribs from beneath. The separation of the loin from the feather bones is different from the other three systems in that it uses two rotating knives placed strategically in front of the bottom saws.

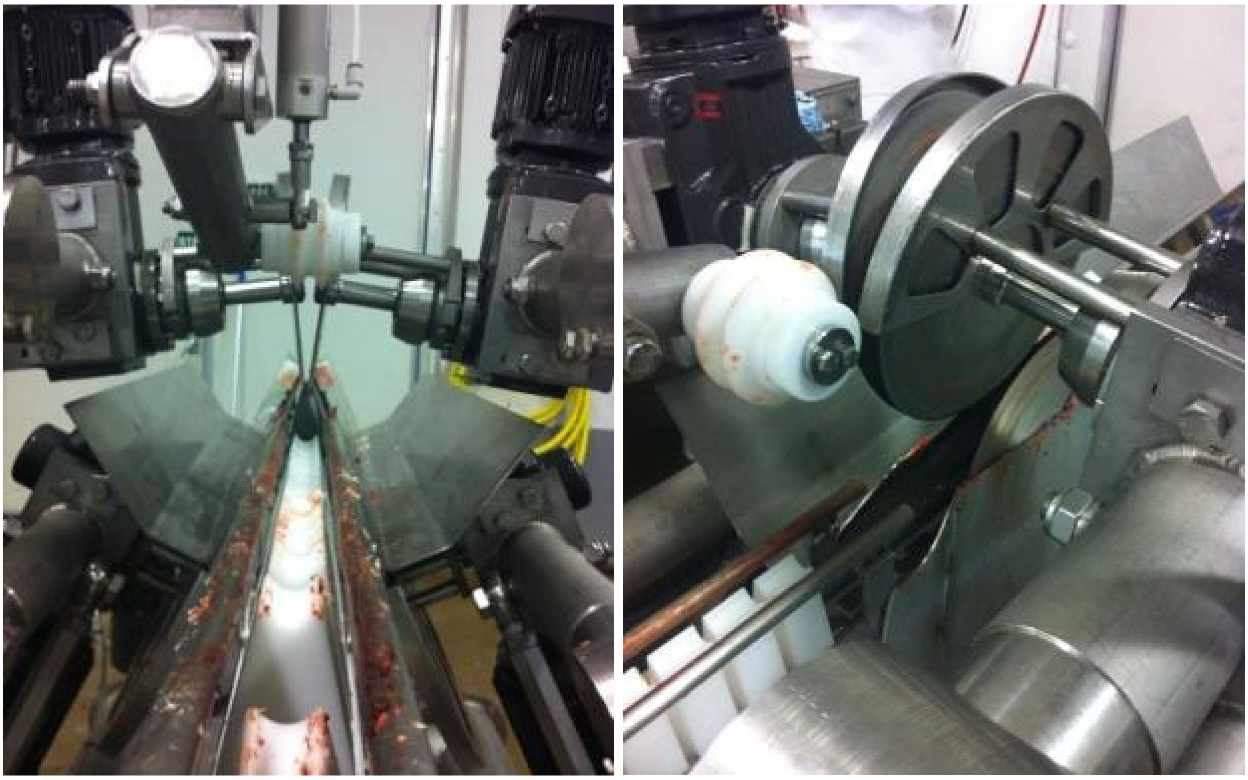


Figure 35: Scott's chine removal system showing top and bottom sets of blades

The right of Figure 35 shows the mechanism used to remove the loin muscle close to the feather bones. The top set of blades is angled inwards from the top. This allows the thicker end of the feather bone to fit between the blades while the rotating blades scrap down against both sides of the feather bone simultaneously. The rotating knife blades are also angled inwards on the leading edge as the rack enters the cutting blades. This creates a knife shearing affect directing the rotating knife blades down against the feather bone to aid in separation of the loin muscle cleanly from the bone.

The rotation of the top knife blades and the radius of curvature as the top of the feather bones enters the wider gap higher up on the blades and moving down the featherbone as the rack passes through the blades works more actively in separating loin from bone than pushing the meat and bone through a stationary blade. It also allows different sized racks to be processed for optimum yield without requiring adjustment to the blade settings.

5.6 Customer Specifications and Yield performance

Cutting lines discussed earlier were compared for each system with resultant yield and finished product quality reported. Ability to remove the ribs closer to the chine bone and with a neater cut plays a large part in delivering higher yields of bone-in racks.

Scrape testing with a sharp boning knife to remove all remaining meat from the loin side of the chine bone was used to measure this yield difference. Left and right sides of racks and yield loss from each side were weighed separately to measure consistency of each machine in cutting down the centre line without skewing to the left or right. Refer to Figure 36 and Figure 37.

Figure 36: Scraping remaining loin from chine and weighing for each side of the chine bone enabled comparison between systems

Figure 37: Racks from a chinning system – note the amount of meat remaining between the loin and the chine bone

All systems were compared back to a manual base-line of yield and the result improvement in yield for each system is reported in the second last column of Table 8. A number of observations should be noted from the table:

- Only yield improvement related to chine removal is counted. Improvement in flap yield on the ATTEC system is not counted here.
- Manual operations differ significantly. When manual bandsaws operators take their time and do their best job performance is more than $1.00/carcase better than operating at speed. But this is still only half as good as the best chining systems. A manual guide helps improve performance but still poses a large OH&S risk.
- ATTEC – Knife ready settings were calculated from actual trial data. The ATTEC – (Est. yield optimum) is not based on actual data but assumes similar performance to an optimised BLM machine which has a similar cutting mechanism.

Table 8: Chine removal yield

CHINE REMOVAL YIELD												
	Untrimmed Rack after chine removal		Rack Yield Benefit vs. manual	Chine		Loin scraped from chine		Rack Value			Benefit vs. Manual Baseline	n-samples
Chine Method	Grams	% of total	Rack %	Grams	% of total	Grams	% of total	Rack $/hd	Render $	Total $/hd	Total $/hd	394
SCOTT (LEAP IV)	1,651	88.29%	8.1%	219	11.71%	25	1.31%	$ 25.10	$ 0.01	$ 25.11	$ 2.29	37
SCOTT (Chine only)	1,642	87.79%	7.6%	230	12.30%	18	0.95%	$ 24.96	$ 0.01	$ 24.97	$ 2.15	38
BLM - S4 Optimised	1,627	86.98%	6.8%	223	11.94%	18	0.94%	$ 24.73	$ 0.01	$ 24.74	$ 1.92	40
MANUAL Optimised	1,576	84.28%	4.1%	289	15.46%	48	2.58%	$ 23.96	$ 0.01	$ 23.98	$ 1.15	35
Manual (Commerial-Baseline)	1,500	80.20%	0.0%	365	19.53%	77	4.13%	$ 22.80	$ 0.02	$ 22.82	$ -	18
Manual (with bandsaw guide)	1,561	83.47%	3.3%	309	16.53%	80	4.27%	$ 23.73	$ 0.02	$ 23.75	$ 0.92	21
ATTEC - (Knife ready)	1,559	83.37%	3.2%	311	16.63%	56	2.99%	$ 23.70	$ 0.02	$ 23.72	$ 0.90	11
ATTEC - (Est. Yield Opt*)	1,627	87.00%	6.8%	243	13.00%	37	2.00%	$ 24.74	$ 0.01	$ 24.75	$ 1.93	0
MACPRO (Chine and Flap)	1,654	88.44%	8.2%	216	11.56%	21	1.12%	$ 25.14	$ 0.01	$ 25.16	$ 2.33	30
(*Trials were only set for knife ready. Data couldn't be collected for optimised yield. Numbers are estimates only based on adjustability of system settings.)												394

5.7 Additional functionality on some systems

A number of the systems have additional capability beyond chine bone removal and are described here.

5.7.1 ATTEC Flap removal length

The ATTEC machine includes a flap removal function. Although not related directly to chine removal, this allows full rack saddles to be loaded onto the machine with the flaps being removed automatically. The length of rack tail is selected from 3 pre-set options. These are controlled by the operator selecting the appropriate rack tail length setting from the digital control panel. Cut lengths can adjust quickly enough to change every rack but is not likely to be done considering normal boning room process flow.

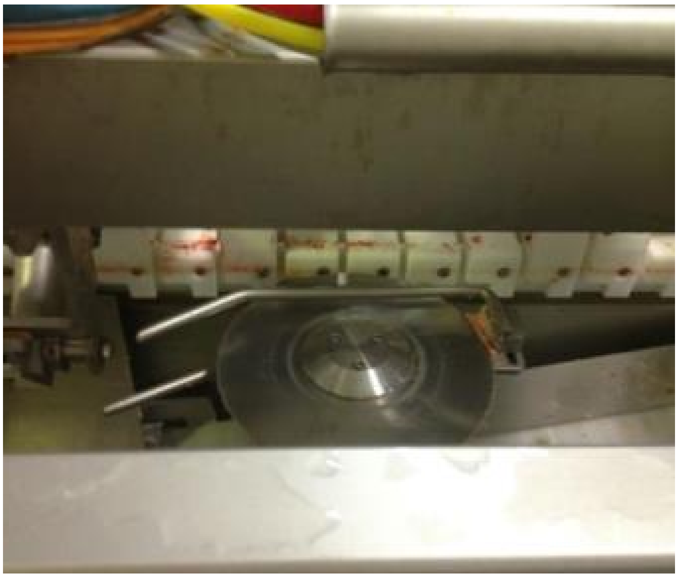


Figure 38: Flap removal saw on either side of conveyor cut adjustable flap lengths

Figure 39: Continuous in-feed conveyor length customised to site requirements. Digital controls change flap length in-line.

5.7.2 Macpro flap removal

The Macpro system has been built with provision for a flap removal system to be installed in the lower portion of the existing system although this has not yet been tested and would come at an additional cost.

5.7.3 Macpro Loin de-boning

The Macpro chining system also includes a loin de-boning module. The operator can switch between loin de-boning (Figure 40) and chining (Figure 41) during production and the technology adjusts its cutting mechanism. For slower line speeds of around 6-7 cuts per minute an operator could alternate between racks and loins. More detail of this function in included in the appendix.

Figure 40: Loin mode (chine saws move out of the cutting path)

Figure 41: Racks and chine bone exit onto the same table

5.7.4 Scott LEAP IV full middle processing

The Scott Technology system was initially developed as a component within their LEAP IV middle deboning system. It is now being offered as a standalone chining module but has the option to be integrated into a middle deboning installation at a later date. The middle system is fully automatically including automatic infeed and exit and removes spinal cord, splits loin and rack, removes loin and rack flaps, and chines rack or splits full middles.

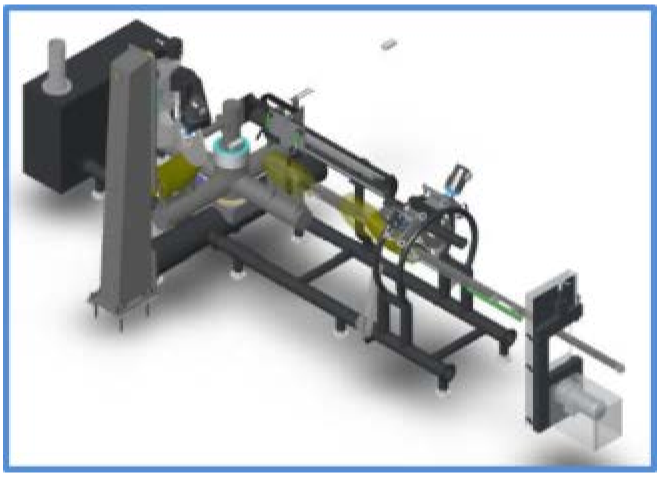


Figure 42: Scott LEAP IV middle de-boning system

5.8 Maintenance

Detailed explanations of each systems mechanical design, timing and power source are detailed in the appendix for each system.

A number of trials of the BLM system across different plants showed a wide variation in yield performance from plant to plant. This gave an indication that maintenance can have a big impact of on equipment performance with a drop in yield. This indicates the importance of daily maintenance to equipment performance and can be just as important in seeking optimum yield as equipment selection.

The systems with static featherbone blades require more attention to blade sharpness.

5.9 Daily setup and clean down

All four systems have differences in daily setup and clean down, but is not enough of a difference to impact on system selection.

5.9.1 Blade sharpening

The Scott systems Feather blades require a light stone every two weeks. The ATTEC, BLM and Macpro feather blades should be stoned more frequently (daily ideally) as they are static and don't have the benefit of a rotating shearing motion to assist in the cutting as the Scotts system does.
Chine blades use a similar cutting process on all four systems which is not significantly different in design. However, the Scott, Macpro and Attec systems use slow-rotating micro-tooth blades that require less frequent sharpening and significantly reduce bone dust as compared with the high speed blades used on the BLM system.

5.9.2 Cleaning

The ATTEC system is the most different to the others. The system takes a similar amount of time to clean as other systems but has a self-cleaning system built into the machine as shown in Figure 43. Attention to detail in cleaning under belts and behind cutting supports is similar to that required of other systems. Perspex safety panels that fully enclose the machines cutting mechanisms lift up for easy cleaning at the end of the day's production. Saw blades are not disassembled for cleaning.

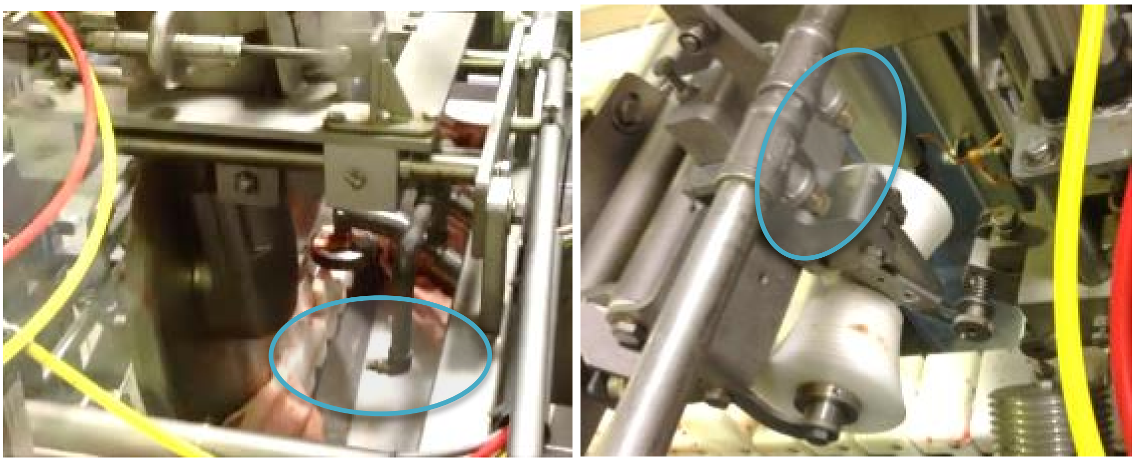


Figure 43: In-built self-cleaning system simplify the cleaning process

The Macpro and the BLM systems do require the blades to be removed at the end of the day but the Macpro has smart blade holders to assist with removal and storage as shown in Figure 44.

Figure 44: Macpro cleaning attachments to enable easy and safe removal and storage of circular saw blades

6 Financial Drivers

An excel based model was developed to compare each systems variation in financial performance. Other costs and operational and financial drivers observed during each trial where built into the model. Factors like throughput, labour required, equipment footprint, ease of integration in processing line, bone defects and secondary inspection, maintenance costs, spare parts costs and replacement frequency, daily maintenance requirements were assessed for each process and system and captured in the model drivers.

The model allows for two approaches:

1. Fixed volume throughput with variable number of systems to achieve this
2. Maximum volume for each individual system

Given the purpose of the document is to compare value between systems, the modelling presented here assumes a variable number of systems to achieve a fixed volume. A comparison of each system running at its maximum volume per hour has been provided in the Appendix but note that volumes per system in that scenario range from 200-580 per hour.

6.1 Plant drivers

A volume of 460 carcases per hour or 3,680 per 8 hour shift has been used from this point on and is included with other plant drivers in Table 9. Based on system processing rate per minute, the number of systems required to achieve the volume is calculated half way down the table. Other key drivers include yield improvement over manual in the bottom of the table, along with cost of product in the sales assumptions to the right hand side. The highest performing yield for the BLM has been used, along with an estimated yield for the ATTEC system as explained in Table 8 on page 28.

Table 9: Plant specific drivers

PLANT SPECIFIC DRIVERS

Operational Assumptions	
Discount rate	7%
Total hours operation/day	8
Total days operation/year	250
Shifts per day	1
Model max throughput (Y/N)? - *alternatively volume you set in Cell E28*	N
Plant volume / HOUR for equipment comparison	460

Sales Assumptions	
Carcase Weight	22
Value of Rack	$15.20
Value of Bones	$0.05
Value of Render	$0.05

Performance Comparisons	Manual Benchmar	MANUAL Optimised	BLM - S4 Optimised	TTEC - (Est. Yield Opt	SCOTT (Chine only)	ACPRO (Chine and Fla
Head / Min.	8.0	4.0	7.0	12.0	12.0	10.0
Machine Capacity (Head/hour)	480	240	420	720	720	600
Spare Capacity (Head/hour)	0	-240	-60	240	240	120
Number of systems *(see Cell C27)*	1	2	2	1	1	1
Head / Shift *(See Cell B27)*	3,680	3,680	3,680	3,680	3,680	3,680
Head / Year *(See Cell B27)*	920,000	920,000	920,000	920,000	920,000	920,000
Yield increase (% of rack)		4.07%	6.78%	6.80%	7.58%	8.24%
Yield increase (kg/head)		0.02	0.07	0.07	0.08	0.09
Labour saving / shift		0	0	2	1	2

Modelling assumes a 1 shift basis at 50 weeks per year when calculating return on investment.

6.2 Value benefits

A range of benefits are provided over manual bandsaw operation and are detailed in Table 10 but the biggest financial benefit is yield with some labour saving as summarised in Figure 45. Although the reduction in OH&S costs is not large, the ability to remove operators from bandsaws on what is quite a dangerous job is worth a lot more in increased safety.

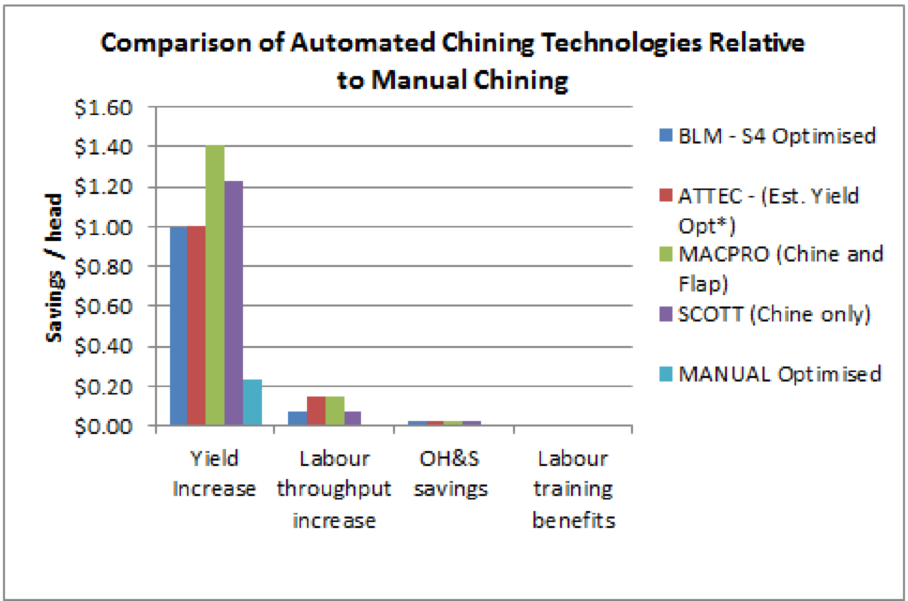


Figure 45: Summary of benefits across all chining methods

The Table 10 takes into account all the value benefits and trade-off in costs to summarise net benefit on a per head basis at the bottom for each system.

Table 10: Cost benefit analysis of each system

Useful working life			10		15		10		10		10	
COBOTIC EQUIPMENT*												
* Each method compared back to Manual Bandsaw												
	lanual Benchma		MANUAL Optimised		BLM - S4 Optimised		TEC - (Est. Yield Op		SCOTT (Chine only)		CPRO (Chine and Fl	
Benefit summary	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit
Yield Increase			$0.23	$211,751	$1.00	$916,276	$1.00	$922,208	$1.22	$1,126,525	$1.41	$1,296,503
Labour throughput increase			$0.00	$0	$0.07	$67,600	$0.15	$135,200	$0.07	$67,600	$0.15	$135,200
OH&S savings			$0.00	$0	$0.02	$20,000	$0.02	$20,000	$0.02	$20,000	$0.02	$20,000
Labour training benefits			$0.00	$0	$0.00	$394	$0.00	$806	$0.00	$403	$0.00	$826
$ Benefit			**$0.23**	**$211,751**	**$1.09**	**$1,004,269**	**$1.17**	**$1,078,215**	**$1.32**	**$1,214,528**	**$1.58**	**$1,452,529**
Capital cost			$0.01	$12,000	$0.02	$14,667	$0.03	$31,500	$0.03	$28,500	$0.04	$33,500
Maintenance Cost			$0.00	$0	$0.00	$712	$0.00	$712	$0.00	$712	$0.00	$712
Operational Cost			$0.02	$22,260	-$0.02	-$18,616	-$0.02	-$19,137	-$0.02	-$17,476	-$0.02	-$19,155
Risk of mechanical failure			$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0
Risk of mechanical injury			$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0
Risk of product damage			$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0
Total cost			$0.04	$34,260	$0.00	-$3,237	$0.01	$13,076	$0.01	$11,736	$0.02	$15,058
Total net $ benefit			$0.19	$177,491	$1.10	$1,007,506	$1.16	$1,065,139	$1.31	$1,202,792	$1.56	$1,437,471

6.3 System return on investment

The system return on investment calculates how quickly the net benefit per head will recover the total capital cost, based on the number of systems required to achieve the volume. Note the slower time to pay back the BLM system is due to requiring two systems for the larger volume.

Table 11: Summary performance measures based on consistent volume across all systems

	Manual Benchmark	MANUAL Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and Flap)
Capital cost	$60,000	$120,000	$220,000	$315,000	$285,000	$335,000
Number of systems *(see Cell C27)*		2	1	1	1	1
Gross return Per head		$0.23	$1.09	$1.17	$1.32	$1.58
Total costs Per head		$0.04	$0.00	$0.01	$0.01	$0.02
Net Benefit Per head		$0.19	$1.10	$1.16	$1.31	$1.56
Annual Net Benefit / unit		$88,746	$1,007,506	$1,065,139	$1,202,792	$1,437,471
Annual Net Benefit		$177,491	$1,007,506	$1,065,139	$1,202,792	$1,437,471
Pay back (months)		8.11	2.62	3.55	2.84	2.80
NPV		$1,126,625	$8,956,280	$7,166,090	$8,162,909	$9,761,196

In smaller plants the BLM and Macpro systems provide a more comparable return on investment as shown in Table 12 (assumes different production for each system based on it's maximum throughput) than where one systems capacity is better matched to plant throughput, and in ___ where all systems operate at 380 head per hour.

Table 12: ROI based on each system operating at its own maximum throughput

	Manual Benchmark	MANUAL Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and Flap)
Capital cost	$60,000	$60,000	$220,000	$315,000	$285,000	$335,000
Number of systems *(see Cell C27)*		1	1	1	1	1
Gross return Per head		-$0.04	$1.09	$1.20	$1.37	$1.59
Total costs Per head		$0.01	$0.00	$0.01	$0.01	$0.01
Net Benefit Per head		-$0.05	$1.09	$1.19	$1.37	$1.58
Annual Net Benefit / unit		-$22,921	$1,047,344	$1,713,787	$1,966,924	$1,895,759
Annual Net Benefit		($22,921)	$1,047,344	$1,713,787	$1,966,924	$1,895,759
Pay back (months)		-31.41	2.52	2.21	1.74	2.12
NPV		($220,988)	$9,319,121	$11,721,923	$13,529,850	$12,980,020

Table 13: ROI based on production of 380 carcases per hour across all systems

SUMMARY PERFORMANCE MEASURES*

* Each method compared back to Manual Bandsaw

	Manual Benchmark	MANUAL Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and Flap)
Capital cost	$60,000	$120,000	$215,000	$315,000	$285,000	$335,000
Number of systems *(see Cell C27)*		2	1	1	1	1
Gross return Per head		$0.23	$1.11	$1.21	$1.34	$1.61
Total costs Per head		$0.05	$0.00	$0.02	$0.02	$0.02
Net Benefit Per head		$0.19	$1.11	$1.19	$1.32	$1.59
Annual Net Benefit / unit		$70,332	$841,318	$904,755	$1,006,875	$1,211,992
Annual Net Benefit		$140,665	$841,318	$904,755	$1,006,875	$1,211,992
Pay back (months)		10.24	3.07	4.18	3.40	3.32
NPV		$867,972	$5,694,063	$6,039,619	$6,786,867	$8,177,527

6.4 Assumptions

Capital and installation costs are summarised in Table 13. Note the total cost of capital accounts for the number of units required.

Table 14: Capital and operational costs

Capital purchase and installation	Manual Benchmark	Manual Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and
Number of Units	1	2	2	1	1	1
Equipment purchase / Unit Cost	$ 60,000	$ 60,000	$ 215,000	$ 290,000	$ 260,000	$ 310,000
Total equipment capital	$ 60,000	$ 120,000	$ 430,000	$ 290,000	$ 260,000	$ 310,000
Installation		$ -		$ 10,000	$ 10,000	$ 10,000
Conveyors		$ -		$ 15,000	$ 15,000	$ 15,000
Total Cost	**$ 60,000**	**$ 120,000**	**$ 430,000**	**$ 315,000**	**$ 285,000**	**$ 335,000**
Annual Capital Cost	$ -	$ 12,000	$ 43,000	$ 31,500	$ 28,500	$ 33,500
Annual Capital Cost per head	**$ -**	**$ 0.013**	**$ 0.047**	**$ 0.034**	**$ 0.031**	**$ 0.036**

Maintenance costs have been assumed to be similar for all systems as there is no history of operation for 3 of the 4 systems reviewed. Details of equipment design are included in the appendix and don't indicate a large difference in complexity of the systems for ongoing repairs and support.

Labour savings does have an impact on the operation of the systems with the ATTEC system in particular saving an additional labour unit as a result of automatic removal of the rack flaps. Table 14 summarises the savings in labour for each system on a per head basis in the top section and in relation to FTE's saved in the bottom half of the table.

Table 15: Labour savings for each system

Increased throughput through the room			Manual Baseline	Manual Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield	SCOTT (Chine only)	MACPRO (Chine and
Average daily hd			3680	3680	3680	3680	3680	3680
Average kg			22	22	22	22	22	22
Average Kg boned per day			80,960	80,960	80,960	80,960	80,960	80,960
Boning room cost / hour			$127	$127	$94	$60	$94	$60
Boning room cost / day			$1,019	$1,019	$749	$478	$749	$478
Labor cost \ per kg to bone			$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
Labor cost \ per hd to bone			$0.28	$0.28	$0.20	$0.13	$0.20	$0.13
Labour productivity savings/ head			**$0.00**	**$0.00**	**$0.07**	**$0.15**	**$0.07**	**$0.15**
Task	**Rate / hour**	**WW Loading** 30.00%	**Number of labor units**					
Band Saw - Rack split & chine	$26.00	$33.80	1	1	0	0	0	0
Band Saw - Flap removal	$26.00	$33.80	1	1	1	0	1	0
Boners	$23.00	$29.90	2	2	1	1	1	1
Knife hand	$23.00	$29.90						
Packer	$23.00	$29.90						
General Labor	$23.00	$29.90			1	1	1	1
Maintenance	$19.00	$24.70						
Total FTE's required			4	4	3	2	3	2
Number of systems required			1	2	2	1	1	1
Total labour required			4	4	4	2	3	2
Labour units saved			**0**	**0**	**0**	**2**	**1**	**2**

Although the saving in training is only small, it has been calculated in Table 15 and included in the total figures.

Table 16: Staff training cost reductions

Staff training costs								
Staff turnover rate		30%						
Reduction in staff trained each year			0.00	0.00	0.00	0.60	0.30	0.60
Reduction in hrs required to train beginners			40	43	41	42	42	43
Hourly training cost			$32.00	$32.00	$32.00	$32.00	$32.00	$32.00
Saving per trainee			$1,280	$1,376	$1,312	$1,344	$1,344	$1,376
Total Saving			$0.0	$0.0	$0.0	$806.4	$403.2	$825.6
Saving per hd			**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**

Occupational health and safety costs have significant impact on a workforce if a major injury or amputation occurs. The cost of major bandsaw accidents and reduction in sprains and strains in these roles has been estimated from industry figures. Savings in these costs as a result of removing labour from bandsaws has then been calculated in Table 16.

Table 17: OH&S Benefits

OH&S Benefits		Manual Baseline	Manual Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and Flesh)
Band Saw cutting							
Average cost of bandsaw accidents over 5	$120,000						
Risk of Limb Loss over 5 year period		0%	100%	0%	0%	0%	0%
Annual Cost		$0	$24,000	$0	$0	$0	$0
Annual Saving		**$0**	**-$24,000**	**$0**	**$0**	**$0**	**$0**
Annual Saving per head		**$0.00**	**-$0.03**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Sprain and Strain from lifting							
Cost of light duties claim, loss of operator	$5,000						
Number of occurrences per year		4	0	0	0	0	0
Annual Cost		$20,000	$0	$0	$0	$0	$0
Annual Saving		**$0**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**
Annual Saving per head		**$0.00**	**$0.02**	**$0.02**	**$0.02**	**$0.02**	**$0.02**
TOTAL OH&S Benefit per annum		$0	-$4,000	$20,000	$20,000	$20,000	$20,000
TOTAL OH&S Benefit per head		$0.00	$0.00	$0.02	$0.02	$0.02	$0.02

The impact of ongoing operational costs can be quite significant when considering replacement of large expensive blades. These costs for each system are summarised in Table 17. Given the short operating life of these systems the figures should still be considered very much estimates until a long history of operation is built up.

Table 18: Operational cost estimates

Operational Cost			Manual Benchmark	Manual Optimised	BLM - S4 Optimised	ATTEC - (Est. Yield Opt*)	SCOTT (Chine only)	MACPRO (Chine and
Blades (Annual Cost)			$ 22,260	$ 44,520	$ 3,640	$ 3,640	$ 4,784	$ 3,100
	Blade unit cost		$ 29.68	$ 29.68	$ 155.00	$ 29.68		
	Feather Blades (pair)						$ 1,144	$ 1,600.00
	Circular saw blades (pair)				$ 3,640	$ 3,640	$ 3,640	$ 1,500
	Blades / day		3	3	0.0040	0.0040	0.0040	0.0040
	Number of systems		1	2	1	1	1	1
Cleaning (Annual Cost)			$ 1,291	$ 1,291	$ 1,291	$ 775	$ 1,291	$ 1,291
	Cleaning rate	$ 20.66						
	Daily Time		0.25	0.25	0.25	0.15	0.25	0.25
	Daily Cost		$ 5.17	$ 5.17	$ 5.17	$ 3.10	$ 5.17	$ 5.17
Power	kW			$ -	4.00			5.50
Service Contract				$ -				
Ongoing Training				$ -				
Total annual cost			$ 23,551	$ 45,811	$ 4,935	$ 4,415	$ 6,075	$ 4,397
Cost per head			**$ 0.026**	**$ 0.050**	**$ 0.005**	**$ 0.005**	**$ 0.007**	**$ 0.005**

6.5 System summary

Table 19: Summary of system capabilities

Capability	Sub- Capabilities	Definition	Manual Benchmark	Manual Optimised	BLM	ATTEC	SCOTT (LEAP IV middle machine)	MACPRO
Process Flow	Equipment footprint (m2)	The system will be able to fit in most boning rooms as it is of a minimal size.	$4m^2$	4m2	6m2	10m2	15m2	4m2
	Rack Chinning Speed (racks/min)	Number of racks chinned per minute by one system		4.0	8.0	12.0	12.0	10.0
	Noise impact	The system shouldn't affect noise in the room		✓	✓	✓	✓	✓
	In-line adjustment to settings	Time required to adjust system settings for different cutting specifications. Unless the system has on-line adjustment to do multiple cuts OR adjust for different size carcases yield performance or utilisation will be sub-optimal.	Single spec - manual operation does not have the accuracy to adjust chine removal for different customer specs that allow yield to be optimised.	Some ability to adjust cut angle by changing guide angle between carcase or customer runs. Changeover is ~60 seconds.	No in-line adjustment - Choice of two cutting guides adjust width between top blades removing loin from spinous process. - Bottom saw blades removing ribs are fixed.	No in-line adjustment of Rack angle - Angle of blades removing chine take maintenance ~2-3 minutes In-line adjustment of flap length - Operator presses button selecting 3 pre-set Flap lengths at line speeds but does not measure from end of eye muscle.	No in-line adjustment of Rack angle - Angle of blades removing chine take maintenance ~2-3 minutes In-line adjustment of flap length - Fully automatic adjustment of flap length on individual racks based on image analysis taken from end of eye muscle.	- Operator turns lever selecting 2 pre-set bottom saw widths/angles at line speeds - Operator turns lever switching between Chine and Loin deboning in 15 seconds - Blade system is self-adjusting ("floating") by following key parts of the bone geometry.
	Loading	Method of presenting rack for automated chining.	Manual	Manual	Manual	Manual	Automatic	Manual
	Unloading	Method of removing processed rack and off-cuts from machine.	Manual	Manual	**Manual** - removal of chined racks. **Automatic** - exit of chine bone on side roller belt.	Automatic - 1 conveyor belt.	Automatic	Automatic - 1 conveyor belt.
	Continuous (In-line) or batch processing	All systems require manual loading so none are truly in-line except SCOTT LEAP IV. All can be integrated into continuous production systems with conveyor belt.	- Continuous processing with conveyor belt.	- Continuous processing with conveyor belt.	- Continuous processing with conveyor belt.	- Continuous processing with conveyor belt.	- Continuous processing with conveyor belt. - Integration with LEAP IV middle processing makes this truly continuous as no labour is required to run the machine.	- The multi-function chining and loin de-boning make this ideal for smaller batch processing. - Can operate in a continuous process when only using the chining function (not switching between rack and loin).
	Safety	Risk of injury	Extreme risk of amputation. Bandsaw guide can protect operator and improve consistency.		Safe - Carriage moves rack into machine without operator intervention. Manual repetition required to load and unload racks.	Safe - Carriage moves rack into machine and exits without operator intervention.	Automatic load and unload eliminates operator.	Safe - Safety door closes to activate process. Automatic removal of rack without operator intervention.
	Process flow maintained from manual	No additional staff or modifications to the process flow are required to accommodate the machine	Manual baseline	Manual baseline	Apart from floor space and installation minimal adjustment to process required.	Adaptation to process line, particularly on outfeed required in addition to floor space required.	Significant floor space and adaptation after primal cutting required to install system.	Apart from floor space and installation minimal adjustment to process required.
	Process flow improvement	Requires adjustment to manual process flow but results in increased productivity	Manual baseline	Manual baseline	Some benefit but limited due to manual load and unload of machine.	Batch infeed limited by operator loading. Outfeed improves process to a degree.	Significant improvement in productivity has been experienced (*>15% when integrated with LEAP III*)	Batch infeed limited by operator loading. Outfeed improves process to a degree.

Product specifications	Loin removal method				Featherbone pushed between 2 stationary blades	2 blades cross cut from top of chine to bottom of rib consecutively	2 rotary knife blades cut down on chine bone	Mul
	Rib removal method				Rotary saw blades remove ribs.		2 rotary saw blades cut ribs.	Rot
	Adjustment of loin / chine separation				2 widths of stationary blades for small or larger width chine bones.	Angle of chine and rib not independent of each other due to blade cutting top and bottom. Requires engineer.	Adjustable angle, lead distance and height. Requires engineer.	Bla ("f
	Adjust angle of rib/maxillary process separation				Some adjustment but requires engineer.		Adjustable angle and height. Requires engineer.	Ad se Adv
	Adjustable chine/rib separation		Manual	Manual	Manual	Unknown	Unknown	
	Rack size/weight Adjustment				Not in-line	Not in-line	Not in-line	
	Presentation of racks		Improved	Baseline	Improved consistency when maintained.	Improved consistency when maintained.	Improved consistency when maintained.	In
Technical Aspects	Multifunction capability	Other functions the system delivers or integrates in with.	N/A	N/A	N/A	Conducts flap removal at pre-set selectable rack tail lengths	Flap removal automatically per carcase. Plus many middle processing functions.	Con sele Shor inte swit chin Prov syst rem
	Affect on Shelf Life		Manual baseline	Manual baseline	Reduction in bone dust	Reduction in bone dust	Reduction in bone dust	

	Yield recovery (Measured)	Data collected during plant trials		4.07%	6.78%	6.80%	7.58%	
	Yield recovery (Estimated potential)	Potential yield with machine optimised for yield. Some machines trialled were optimised for customer butchering, not for yield so increased yields have been estimated based on machine adjustability.			as above.	~1.5% - Limited by single blade removing chine AND rib.	~+0.1% Based on previous trials of machine.	co b
	Staff Savings		0	0	1	2	1	
	Cost of System				$ 220,000	$ 315,000	$ 285,000	$
Return on investment	Power consumption (kW)	What affect will the system have on energy status of the plant? Can this cost be offset by something else.			4.00	0.00	0.00	
	Consumables / Blades ($/day)	Saving over bandsaw blade replacement.			N/A	N/A	N/A	
	Cleaning Costs					Clean-in-place self cleaning sprays reduce manual cleaning time. This offsets machine size so system is not different to clean than other systems.		
	Maintenance costs	The system has a high number of moving parts which increases the costs of operation for the system						

7 Appendices

7.1 List of Tables

7.2 List of Figures

7.3 Attached PDF copies of the equipment reports

- Macpro
- BLM
- ATTEC
- Scott Technology