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final report

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Automated lamb barrel breakup

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Executive Summary

Processors of meat around the world, and particularly in Australia, continue to use band-saws for carcass and primal cutting. In addition to safety concerns with band-saws, they contribute to yield losses and compromise quality as well as shelf life.

The project at Junee Abattoirs, under this AMPC-MLA PIP project, has been aimed at developing a machine that is capable of performing cuts on a whole barrel from lamb carcasses in the range 14Kg to 32Kg. Figure ES1, presents the approach to the Whole Barrel Breakup. Lamb carcasses are generally divided into three, cuts A (at the 4th-5th rib) and B, giving the shoulder, the middle (whole barrel) and the leg primal cuts.

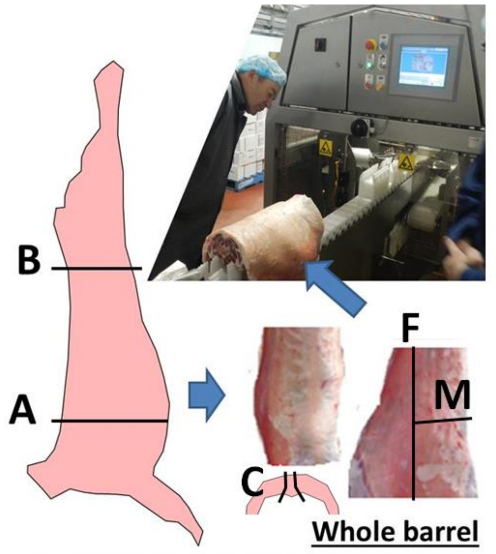

Figure ES1. Whole barrel and the ATTEC LWBM.

The objectives of the project has been to research and develop a machine (Lamb Whole Barrel Machine – LWBM) that breaks up the whole barrel, performing the flap cuts (F), then separates the loin saddle and the rack saddle (middle cut M), and removes the chine and featherbone (C) in one piece from the rack saddle, at 300 barrels per hour.

The manual process involves the breakup of the whole carcass into primal pieces as shown in Figure ES2.

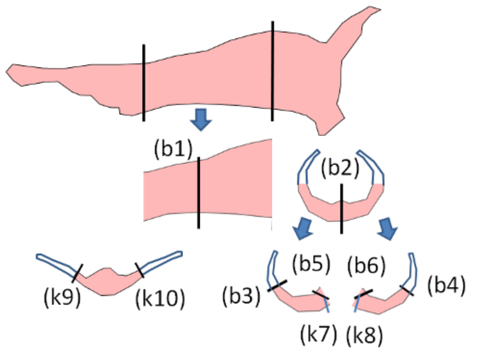

Figure ES2: Manual cuts on a whole barrels.

i) The whole carcass has the shoulder and the leg primal pieces removed to give the whole barrel (middle) primal.

ii) Of interest to this project has been the whole Barrel, which is generally cut on a band-saw into two (cut b1) giving the loin and rack barrels as shown in Figure ES2.

iii) The rack barrel is split (b2) by band-saw and then cut for a 100 mm (or as specified) rib length by band-saw, separating the flap (b3 and b4). The racks are chine boned by band-saw (b5 and b6) in the conventional manner. The featherbone on each rack is separated by knife (k7 and k8).

iv) The loin barrel has the flap separated by knife (k9 and k10). The flap pieces from the loin are sold as trim.

Benchmarking of current process reveals that the racks cut manually are generally over 8 ribs. Consistent rib length is required as measured from the tip of the rib on the rack, where it is separated from the flap, to the edge the eye muscle (Figure ES3). The measurements of manual performance show a spread from 75mm to 115mm, with the average being 94mm, when targeting 100mm rib length racks. Measurements reveal that 1 mm rib of length (with cap off) weighs 1.63g, for an average size lambs.

Rib length at shoulder face of the whole barrel (note that shoulder was separated manually by band saw prior to flap cutting on the ATTEC LWBM)

Figure ES3. Rib length on the rack

The whole barrel machine, as conceived by BMC and manufactured to BMC specification and design, by ATTEC Denmark, was delivered to Junee and tested. Figure ES3 and ES4 show the machine in test position and resulting cuts from trials.

The trials with the prototype machine, after iterative modifications and tuning to breakup of lamb whole barrel from carcasses 14 Kg to 32 Kg at Junee, reveal a potential benefit of over AU$ 2.50 per lamb.

The ATTEC LWBM under this MLA-AMPC PIP project with Junee Abattoirs eliminates a minimum of 6 band-saw action per rack and 4 knife operations. This gives considerable OH&S and efficiency advantage in addition to the yield and quality benefits.

The Machine has been placed in the care of ATTEC Australia for commercial upgrade and marketing to the Australian Meat Industry.

Junee First trial small and large				All weights in kg		All lengths in mm	
Lamb Weight	Whole Barrel Weight	Combined Rack Weights	Chine Bone Weight	Left Rack Rib length Cranial	Left Rack Rib length Caudal	Right Rack Rib length Cranial	Right rack Rib length Caudal
19.3	6.26	2.38	0.35	100	105	100	105
33.1	11.12	3.63	0.54	105	105	105	105
				mm	% rack over saddle		
ATTEC LWBM	**A**	**1.50**	**0.45**	**104**	**77%**		
Benchmark	**A**	**1.36**	**0.46**	**94**	**75%**		
					2%	**Gain**	
				10	**mm Gain in rib length**		

Figure ES3. Lamb Whole Barrel Machine with results from smallest and the largest whole barrels: quality and yield.

The project has reached its goals, identifying new opportunities for new research as well as industrial progress. The ATTEC LWBM, commercially available through ATTEC Australia, presents exciting opportunity for the Australian Meat industry. The adoption of the machine is planned, with an invitation to AMPC membership to consider the business potential. BMC, Junee abattoir and ATTEC gratefully acknowledge the support of AMPC and MLA. Without their contribution and continued support, the outcome of this project would not have been possible.

Contents

1. Introduction and objectives

Processors of ovine meat around the world, and particularly in Australia, continue to use band-saws for carcass and primal cutting. In addition to safety issues, there is yield loss and quality as well as shelf life is compromised.

The project at Junee, under this AMPC-MLA PIP project, has been aimed at developing a machine that is capable of performing cuts on a whole barrel from a lamb carcass. Figure 1, presents the approach to the Whole Barrel Breakup. Lamb carcasses are generally divided into three, cuts A (at the 4th-5th rib) and B, giving the shoulder, the middle (whole barrel) and the leg primal cuts. The Whole Barrel Machine is cut by the machine, designed and developed as a first prototype by this R&D project.

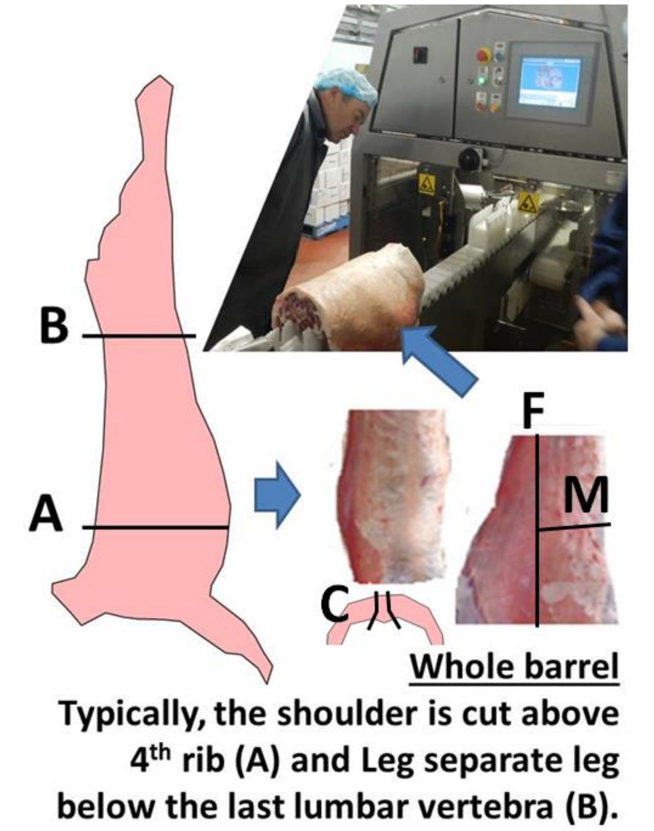

Figure 1. Whole barrel and the ATTEC Whole Barrel Machine.

The objectives of the project to research and develop a machine that performs the flap cut, separates loin saddle and the rack saddle, and then removes the chine and featherbone in one piece from the rack saddle at 300 barrels per hour, has been accomplished.

2. The band-saw cuts and benchmarking

The general manual process involves the breakup of the whole carcass into primal pieces as shown in Figure 2.

v) The whole carcass has the shoulder and the leg primal pieces removed to give the whole barrel (middle) primal.

vi) Of interest to this project has been the whole Barrel, which is generally cut on a

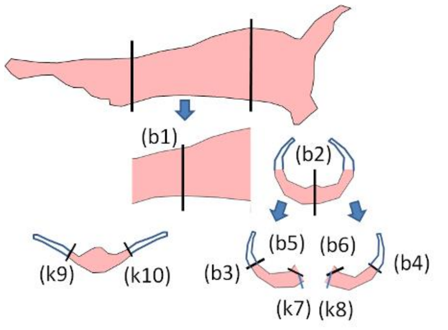

Figure 2. Manual cuts on the whole barrel.

band-saw into two (cut b1) giving the loin and rack barrels as shown in Figure 2.

vii) The rack barrel is split (b2) by band-saw and then cut for a 100 mm (or as specified) rib length on the rack, separating the flap (Figure 2, b3 and b4).

viii) The racks are chine boned by band-saw (b5 and b6) in the conventional manner.

ix) The featherbone on each rack is separated by knife (k7 and k8).

x) The loin barrel has the flap separated by knife (k9 and k10): the flap pieces from the loin are sold as trim.

The benchmarking process performed has focused on the rack rib length to the eye muscle and the yield on rack weight. The results for 35 random rack pairs are given in Table 1. The benchmarking sets a reference against which the yield and cutting performance of the Whole Barrel machine can be assessed.

Table 1 gives estimates based on measurements on an average range of lambs available at the time of measurement (19Kg to 30Kg). Due to operational logistics, it has not been possible to log individual lamb or barrel weights. The important measures for comparison are explained below.

Junee Maunal Cutting Benchmarking 02-12-14					
No.	Combined Pair - Rack Weight	Chine and feather-bone weights	Rib Length Caudal	Rib Length Cranial	Rack Rib Count
1	2.43	0.57	100	105	9.0
2	2.30	0.43	100	90	9.0
3	2.88	0.48	95	95	9.0
4	2.88	0.49	85	90	9.5
5	2.38	0.46	100	100	9.0
6	4.19	0.65	100	100	9.5
7	2.62	0.43	90	95	10.0
8	2.90	0.47	100	100	9.0
9	2.63	0.42	100	105	9.0
10	2.66	0.43	85	105	9.5
11	3.39	0.55	105	110	8.5
12	2.97	0.45	80	85	8.0
13	2.89	0.52	95	105	8.5
14	2.86	0.51	75	90	9.5
15	3.13	0.46	100	115	8.5
16	2.56	0.45	95	100	9.5
17	2.00	0.40	105	110	9.5
18	3.41	0.48	75	95	9.0
19	2.59	0.42	100	100	9.0
20	2.52	0.43	95	105	9.0
21	2.66	0.51	85	105	8.5
22	3.22	0.51	95	100	9.0
23	2.82	0.53	75	105	8.5
24	2.26	0.45	105	95	9.0
25	2.61	0.46	95	100	9.0
26	3.19	0.49	100	100	9.0
27	2.82	0.47	100	110	8.0
28	2.97	0.43	95	95	8.0
29	2.34	0.46	100	95	8.5
30	3.22	0.47	95	95	9.0
31	2.84	0.48	95	95	9.0
32	3.07	0.44	90	100	8.5
33	2.44	0.49	100	105	8.5
34	2.49	0.41	85	110	7.5
35	2.16	0.40	85	100	8.0
	Rack wt Kg	Kg	mm	mm	Ribs
A	1.36	0.46	91	97	8.6
		Rib length average		94	mm
		Rack wt as % of rack saddle			75%

Table 1: Benchmark of the manual process (A=Average).

The separation of loin and rack gives the number of ribs that remain on the rack barrel. The target is 8 ribs. Cutting a 7 rib rack compromises the rack as it will need to be cut for cutlets with extra effort, but retailing at the same price as the 8 rib rack. In all cases observed, where the rack rib count is over 8, cutlets slices are cut from the rack to give an 8 rib rack. The cutlets are packed separately. Partially cut ribs over 8 are trimmed out for a consistent 8 rib rack.

Comparing rib count performance on the rack is indicative of the correctness of the position of the loin-rack cut, which is a new element of the Whole Barrel machine. Note that in the LWBM the middle cut position separating rack and loin saddles is adjustable, but requires the Whole Barrel to have more than 8 ribs to begin with, after main carcass breakup on the band-saw.

Consistent rib lengths of 100mm or over, without compromising quality give higher yield in a rack, with meat and bone on flap left on the rack. The rib length is measured from the tip of the rib at the point of separation from the flap to the edge of the eye muscle on both end of the rack piece, but mainly the shoulder end. The measurements of manual performance show a spread from 75mm to 115mm, with the average being 94mm (Table 1). Note that 1 mm rib length (with cap off) has been measures to be 1.63g.

The calculation of rack yield is benchmarked against the rack saddle weight. This is because the process involves splitting and then band-saw cutting the chine bone, and then knife cutting the featherbone. The weights shown in Table 1 have been derived in stages where the average weight of the chine bone and featherbone combined is 0.46 Kg and the rack weight average as a percentage of the total rack saddle weight is 75%, with a rack weight average being 1.36 Kg over the range of the racks measures.

A new aspect of the whole barrel breakup, which was not considered at the start of the project, is the manual separation of the flap from the loin barrel and the rack barrel as two separate pieces. See cut b1, Figure 2. The Whole barrel machine makes the flap cut in a manner that keeps the flap in one piece, whilst placing the cutting line closer to the eye muscle on the loin section. Cutting whole flaps and keeping the loin saddle in one piece (not split along the spine) is not easily achieved by hand. The Whole Barrel Machine has undergone modifications during the R&D site trials to maximise the transfer of the flap from the loin piece, considered trim, to the whole flap, thus increasing the yield of the whole flap. The

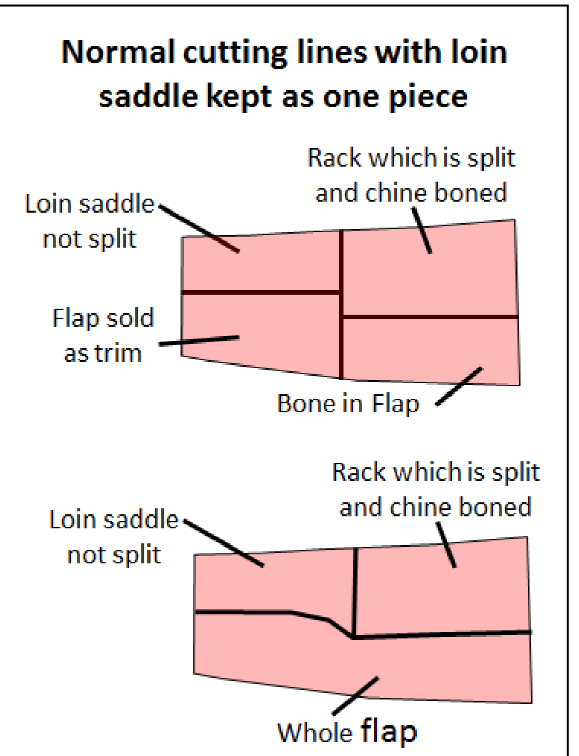

Figure 3. Maximising the flap yield as well as the rack yield.

flap priced is more than double the price of trim. See Figure 3 for the illustration of the approach.

The separation of the chine bone in the manual process breaks up the spine in pieces, which go to waste or rendering. The Whole Barrel Machine chine bones the rack, extracting the featherbone and chine or the whole spine bone from the rack in one piece, suitable as a saleable product.

In the evaluation of the current process for benchmarking bone dust generated from band-saw has not been included, giving a conservative platform to the comparisons, which will be presented later.

The benchmark of the current manual process may be summarised as follows (see Table 1):

- Average rib length on the rack measured from the tip of the rib at the flap cut to the eye muscle achieved by band-saw: 94 mm against a 100 mm specification.

- Rack weight yield from rack saddle is measured at 75% (average rack weight at 1.36 Kg), with chine bone cut in pieces by multiple passes on a band-saw and featherbone cut by knife, both chine bone and featherbone going to waste.

- Rib count on the rack averaging at 8.6 ribs.

- 1mm of rib length, over the length of a rack of average size, has a weight of 1.63 grams.

It is important to note that lambs having 13, 14 or even 15 ribs would not directly give a 4 rib shoulder and an 8 rib rack from the shoulder and the middle cuts. In such situation, there would always be a necessity to trim the loin or the rack for cutlets. Trimming the rack, especially where a whole cutlet can be produced, would be a preference.

3. Requirements overview and the Lamb Whole Barrel Machine (LWBM)

There is important strategic potential for operational capability to be achieved by the introduction of the LWBM (Lamb Whole Barrel Machine). The ability to adjust cut positions by computer setting and to perform cuts under electronic control, provides consistency, especially when making rib cuts or separating the loin and rack sub-primal pieces. This allows programming for different customer specification and a change of recipe for cutting say from 50mm rib length to 100mm rib length at a press of a button, less than 5 seconds. The key here is that the cuts would remain optimised for best yield, which has been achieved based on the understanding reached by the research and development from this and past projects. Using appropriate knife blades in the machine to perform the cuts reduces or eliminates bone dust, with clear benefits in presentation of the meat cuts and quality as well as increased hygiene and effectively shelf-life. In a competitive market these aspect bring considerable business advantage to the processors, with the capability also, to respond and meet market trends.

The specific process and the cuts required from the machine have been as follows (See Figure 4):

1) The whole barrels are to be loaded manually onto the machine carrier, locating the barrel so that it is referenced for cutting.
2) At the press of a button by the operator, the machine to index the whole barrels one by one, after manual loading.
3) The machine to scan the whole barrel to determine the loin-rack cut position as it moves into the machine.
4) The next barrel to be loaded with the carrier static, but as the machine is indexed by operator; the flap cut is performed on the move.
5) At the next index position, whilst the operator loads the machine, the loin and rack separation occurs with the barrel static. After the middle cut, the loin saddle is knocked off
6) The chine and featherbone to be removed during the next index cycle.
7) The cut pieces to exit the machine.

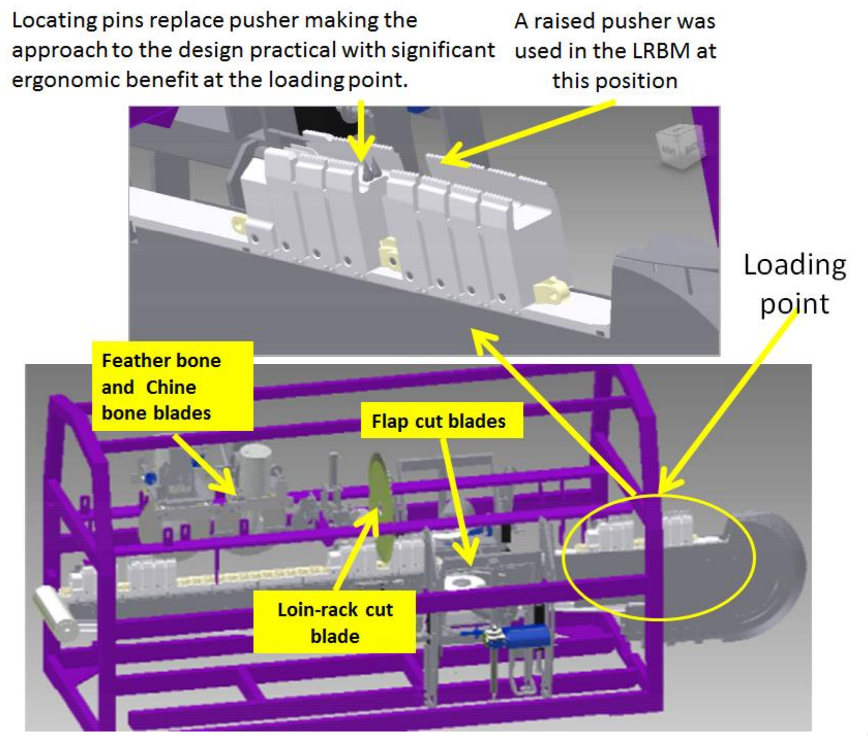

Figure 4. Carrier features and the schematics of the LWBM chain.

The LWBM cuts (Figure 5) are:

2 x whole flaps
1 x loin saddle (not split)
2 x chine removed racks
1 x whole chine and featherbone

Figure 5. Resulting cuts.

4. Measurements and carrier specification

The LWBM is an extended and further developed version of the ATTEC Lamb Rack Barrel Machine, In considering the changes in approach and the adaptation of the features in the LRBM to achieve the cuts, two important aspects have been key from a technical viewpoint.

- Accommodating the variability of the whole barrel in the range 14Kg-32Kg.
- Defining a technical solution that allows easy loading, whilst accommodating for the degrees of variability in lambs as wells as tolerance in positioning inaccuracy by manual loading of the barrel onto the carriers.

4.1 Measurements of variability.

Measurements have put boundaries on the specification of the machine design for breakup as in Figure 6.

Junee LWBM	mm	
Measurements Oct 2012		
	Carcass A	Carcass B
Kg	13.9	32.2
Lnght	900	1180
Wdth	200	280
Barrel measurements		
Carc	**A**	**B**
BL	350	420
BH	240	340
SLC1	190	220
SLC2	160	200
SW	35	45
SH	35	46
FW	8	13
FC	60	60
H1	30	20
H2	40	40
H3	30	20
H1S	80	110
H2S	50	65
H3S	60	85
SPFS	145	230
SPFL	140	100
FCL	90	190

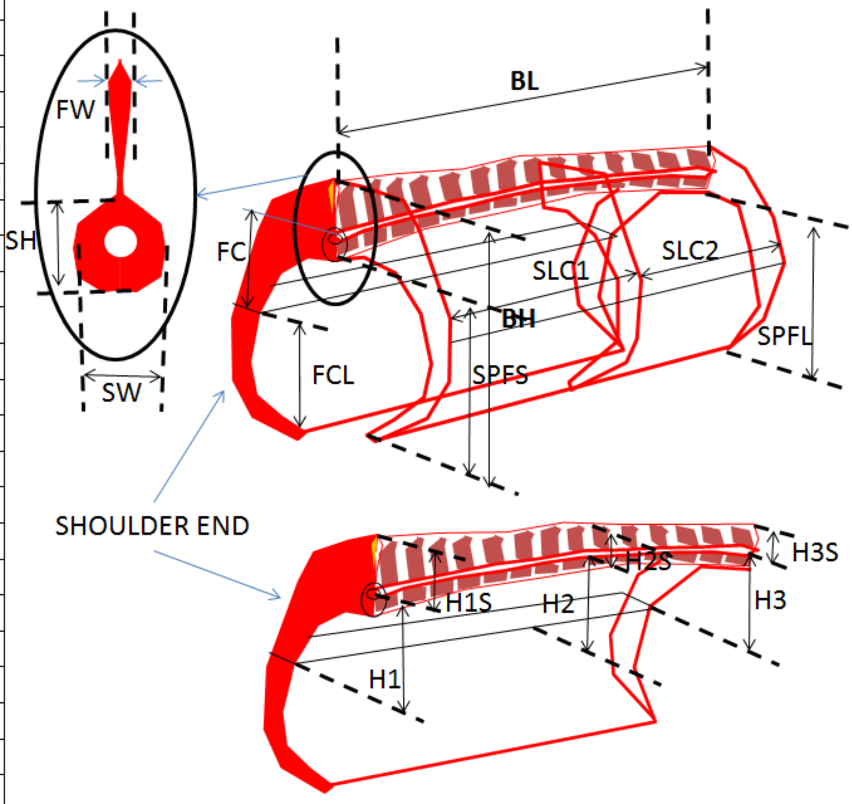

Figure 6. Measurements of Whole Barrels in relation to the design of the LWBM

The relationship between the anatomical variability and cut positions are given in Figure 6, defining the constraints on the design of the carrier (conveyor that takes the whole barrels from the loading point through the cutting stages of the machine).

4.2 Carrier specification

A key constraint in the development of the LWBM has been the carrier design and the available gap on the carrier to allow the Loin-Rack cut (or the middle cut) to be made anatomically for the full range of carcass sizes. A maximum of 70 mm gap on the carrier, where the knife blade can perform the loin-rack separation (See Figure 7) has been achieved.

Based on the trails the middle cut can be performed anatomically with good results for the full range of carcasses.

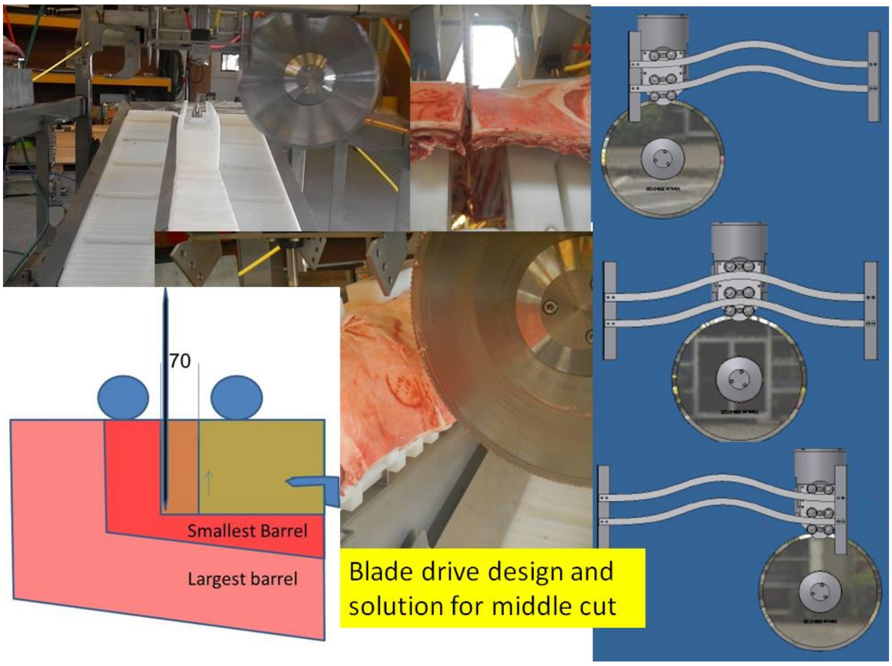

Figure 7. Carrier features and Loin – Rack Blade and cuter drive system.

5. Results and assessment of benefits

Figure 8 shows the main internal features of the ATTEC Lamb Whole Barrel Machine.

The carrier provides a locating feature for the whole barrel and once loaded and pressing of a button indexes the conveyor. After electronic scanning, with the carrier on the move, to determine the position of the middle cut, the whole barrel passes through the flap blades (right to left, Figure 8). Note the on-site modifications allow for locating wheels, above the flap blades, to push the loin section down for a curved flap cut(“S” cut, Figure 3) maximising the flap yield. Then, the carrier stops for the loin-rack blade in a static position. After the middle cut, the loin saddle is knocked off and the carrier moves the rack saddle forward for pre-cutting on both sides of the featherbone and chine bone separation as one piece.

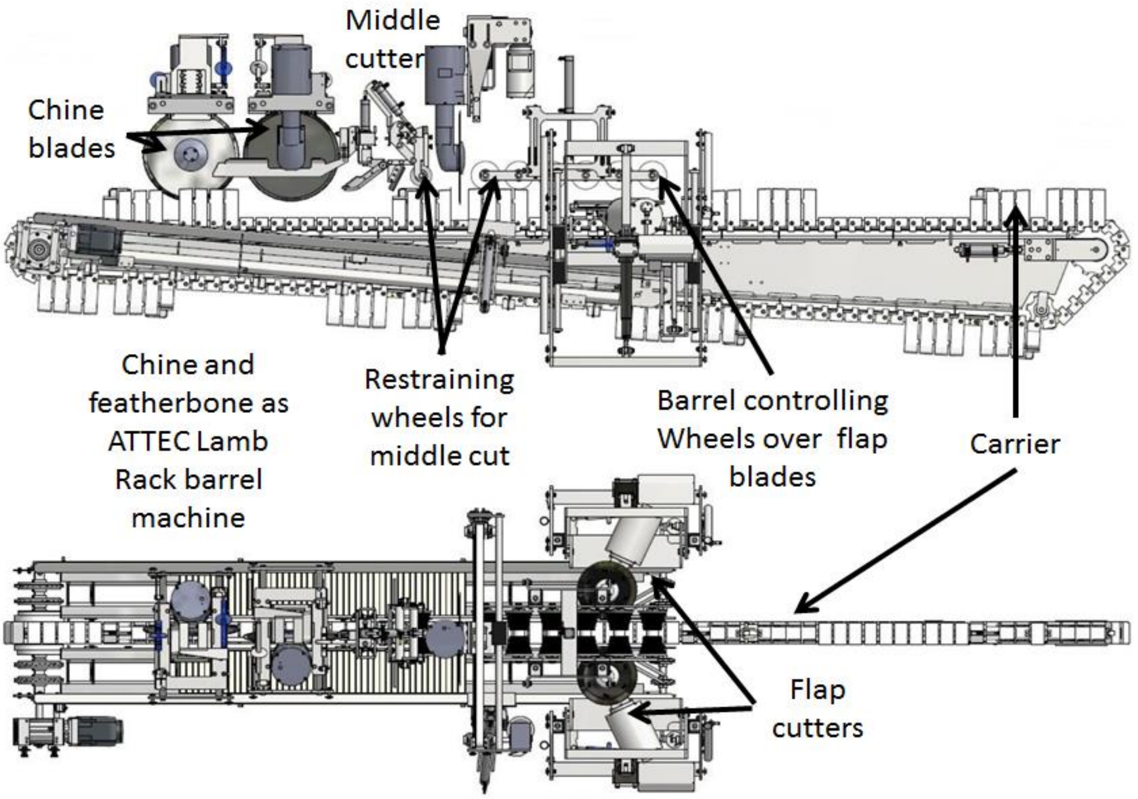

Figure 8. Features of the ATTEC LWBM carrier, barrel handling and cutters.

The whole barrel machine, as conceived by BMC and manufactured to BMC specification and design, by ATTEC Denmark, was delivered to Junee and tested. Figure 9 shows the machine in test position and resulting cuts from trials.

Figure 9. Lamb Whole Barrel Machine in trial position. Smallest and the largest whole barrels cut straight after power up are shown.

The results in Table 2 indicate a gain of 2% in rack yield and an increase in the rib of 10mm on a 100mm length, this being within specification. See Figure 10 for cut images for the small and large barrels of Table 2.

Junee First trial small and large				**All weights in kg**		**All lengths in mm**	
Lamb Weight	**Whole Barrel Weight**	**Combined Rack Weights**	**Chine Bone Weight**	**Left Rack Rib length Cranial**	**Left Rack Rib length Caudal**	**Right Rack Rib length Cranial**	**Right rack Rib length Caudal**
19.3	6.26	2.38	0.35	100	105	100	105
33.1	11.12	3.63	0.54	105	105	105	105
				mm	**% rack over saddle**		
ATTEC LWBM	**A**	**1.50**	**0.45**	**104**	**77%**		
Benchmark	**A**	**1.36**	**0.46**	**94**	**75%**		
					2%	**Gain**	
				10	**mm Gain in rib length**		

Table 2. Results of trial with small and large whole barrels.

The trials indicate an increase in flap cut yield achieved by modifying and allowing the loin section of the barrel to sit lower, without altering the rack position, in the vertical direction. The wheels, over the flap blades are made to push down on the barrel (see Figure 8), as the barrel starts to be cut by the flap blades. This produces the “S” shape cut presented earlier in Figure 3 (bottom, illustration on flap cut line), thus increasing the whole flap yield.

Figure 10. Small – 19.3 Kg lamb (left) and large 33.1 Kg lamb (right) trial cuts.

Table 3 gives the results from further testing using available lambs expanding on Table 2 for the smallest and largest whole barrels. The 87% Rack yield over rack saddle is due to flap cut rib length settings and may be adjusted in normal production. A 110 mm length may be considered excessive, but this is also produced manually.

Junee trial based on available lambs										
No	Whole Barrel Weight	Combined Flap Weight	Combined Rack Weight	Chine Bone Weight	Rib Count	Left Rack Rib Length Cranial	Left Rack Rib Length Caudal	Right Rack Rib Length Cranial	Right Rack Rib Length Caudal
1	9.70	2.86	2.96	0.50	8.0	100	115	100	110
2	9.00	2.48	3.00	0.46	8.0	105	120	100	100
3	10.34	2.80	3.28	0.50	8.5	105	120	110	105
4	10.38	2.60	3.38	0.42	7.5	100	110	100	105
5	8.74	2.46	2.68	0.48	8.0	100	100	100	105
6	9.48	2.68	2.82	0.48	8.5	100	105	100	100
7	9.98	2.72	3.16	0.42	8.0	100	120	100	120
8	8.54	2.56	2.54	0.50	8.5	95	120	100	115
9	9.72	2.52	3.16	0.40	7.5	100	105	100	105
10	8.50	2.10	2.76	0.44	8.0	105	110	105	110
11	8.00	2.16	2.68	0.42	8.0	100	105	100	100
12	8.82	2.28	2.90	0.46	8.0	110	110	105	110
	Averages	2.52	2.94	0.46	8.04	102	112	102	107
			Average rib length			106			
	Rack % on saddle		87%						

Table 3. Results from Lambs available in the range 22Kg to 30Kg.

Measurements of Figure 11 show, an increase of 450g in whole flap weight. The price difference between whole flap and loin flap as trim is about A$ 2.5/Kg.

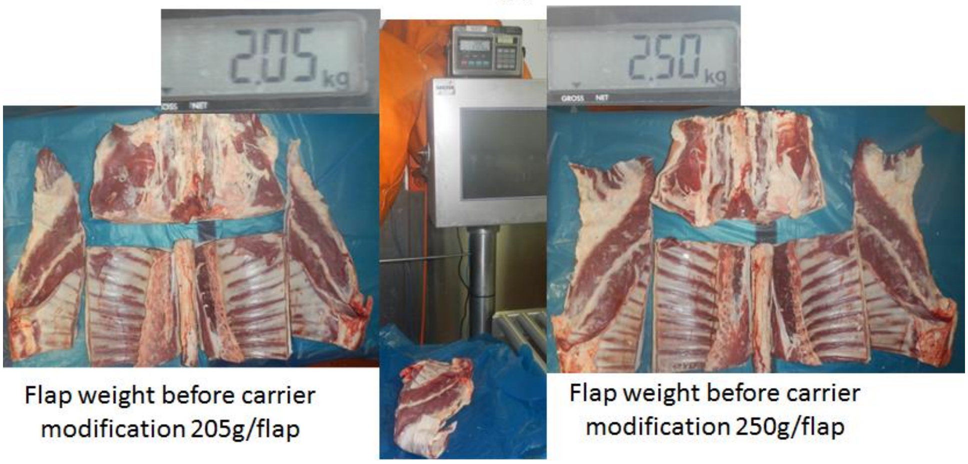

Figure 11. Flap yield increase by average 450g per Whole Barrel based on modifications of the carrier and changing the dynamics of handling using pressure wheels during the flap cut.

Table 4 gives a comparison of the manual and automatic process when using the LWBM. Note that the rib length is above the specification but acceptable and the rib count average marginally over 8, which is the target.

Manual vs ATTEC LWBM		**Av.Rack weight**	**1.2**	***Junee trials Dec 2014***		
	All in Kg or mm	**Manual**	**LWBM**	Difference	wgt increse	
1	Rack weight average %	75%	77%	2%	0.05	
2	Flap weight average increase (Kg)	N/A	0.45	N/A	0.45	
3	Saleable chine bone weight	Nil	0.46	N/A	0.46	Total A$/y
4	Rib Count	8.6	8.04	AU$ Flap	1.13	540,000.00
5	Rib length average on 100 mm	94	104	AU$Rack	0.72	345,600.00
	LWBM Potential economic benefits			AU$ Chine	0.69	331,200.00
2.50	A$/Kg between Flap and trim is assumed	Potential gain Total per carcass (A$)			2.54	
15.00	A$/Kg for Rack is assumed		Carcasses per hour		300	
1.50	/Kg for chine and featherbone as one piece		Hours per year		1600	Check
			Total A$/year		**1,216,800.00**	1,216,800.00

Table 4. Comparison of manual vs LWBM and $ calculations

In the comparison, a 2% weight increase has been applied in respect of Rack yield against the Rack Saddle. The benefits from Flap yield and sale of Chine-bone have also been included (see Table 4). The calculations suggest an overall benefit of higher than A$ 2.50/lamb.

The ATTEC LWBM eliminates a minimum of 6 band-saw action per rack (note that chine boning manually may need additional band-saw passes) and 4 knife operations. This gives considerable OH&S and efficiency advantage in addition to the yield benefits described. Quality is also improved significantly (See Figure 12).

Figure 12. Quality of cuts.

6. The change process

With the technical feasibility of the LWBM reached the following are important considerations for a processor:

- Formation of an adoption team to plan the next steps in the project such as:
  - Location of the machine in the overall stages of the production
  - Services and service connections

    - Timing and steps in the commercial installation
    - Roles and responsibilities
    - Training of operators, cleaners, engineers and supervisors/managers
    - Communication and process of operation post installation involving all departments in the company (sales, finance, QA, operations, etc.)
- The range of products to be put through the machine. This is important given the range of 14Kg-32Kg. The operations team are to consider the current process and how exceptions are to be managed.
- Room layout for day to day running.
- Allocation of responsibility and clarification of roles for operators and supervisors ‘owning’ the new process and the LWBM.
- Consideration of QA functions and change processes required as a result of the use of the LWBM.
- Establishment of administrative and documenting processes to monitor savings and operating cost pre- and post- LWBM. This establishes formal tracking of progress and documents the operational use as well as the sensitivity of the gains (economic or otherwise), dependency on the lamb range, seasonal variations and other important data, for better planning.

7. Concluding remarks

The project has developed a working prototype machine for the breakup of whole barrel from lambs in the range 14 Kg to 32 Kg. The machine has a maximum speed of 300 barrels per hour.

A benefit of over AU$ 2.50 per lamb is calculated from the machine based on trials under this MLA-AMPC PIP R&D project.

The ATTEC LWBM eliminates a minimum of 6 band-saw action per carcass and 4 knife operations. This gives considerable OH&S and efficiency advantage in addition to the yield benefits. Quality is also improved, especially where rotary knife blades have replace band-saw cutting.

The LWBM is placed in the care of ATTEC Australia for commercial upgrade and adoption into the Australian Meat Industry.

The results present exciting opportunities based on the outcome and quantified potentials for a meat business. Processors are strongly encouraged to take advantage of the benefits as identified, quantified and reported by this AMPC-MLA PIP project.