Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

# Beef Chuck Chining

## LEAP4Beef-Module L4B06 Project 0 – Chuck Chining cell concepts


Project code
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# 1 Abstract

The project was to build a test rig and demonstrate mechanised chining of the beef chuck portion. And provide findings that support the benefit of this strategy and development of a chuck chining machine.

A test rig was developed to demonstrate mechanised chining of the beef chuck portion. The rig demonstrated the practicality of a clamping means and cutting the chine cut with a circular saw. With the mechanised chine cut trials, the beneficial yield was shown.

A standalone chuck chining machine has been proposed, suitable for processing 164 head per hr.

The benefit to a processor, and by extrapolation to the industry, is significantly influenced by the market values of spine bones, chuck, chuck rib sets and trim.

The payback could be between 1.1 years and no payback.

Given the significance of the highly variable market values on payback, it is recommended that further input is required from the beef processors to establish the justification for the development of a specific chuck chining machine.

# 2 Executive summary

*Purpose of the research*

There is an opportunity to automate the removal of the chine bone from the beef chuck, targeting yield improvement, labour saving and improved operator safety.

This project has focused on addressing the knowledge gaps identified in the previous exploratory project (Thomson, 2024).

*Target Audience*

The main target audience is the Australasian beef processing industry

*Benefit of the results*

The results of the research will form a business case for proposing a prototype machine development project. With the desired outcome being the development of a prototype which will contribute value, by way of yield, labour saving and improved safety, to the Australasian beef industry.

*The objectives and delivery of the project were:*

- To develop and trial processing methods for the L4B06 Module – chuck chine bone removal.
- Adapt prior learnings from the L4B01 Module – Striploin Chine Bone Removal unit.
- To trial basic materials handling and cutting methodologies.

- The success of this project will provide the steering group including Scott with the information required to determine the first stage requirements for development of a L4B06 Chuck chine removal concept and inform LEAP4Beef strategy moving forward.

*Methodology employed*

The background was pre-empted by research performed in (Thomson, 2024), where the chining of a chuck was simulated manually. This project developed a test rig that demonstrated mechanised chuck chining.

A key metric is the judgment of the meat quantity that can be retained on a higher value portion by mechanised chining.

*Results/key findings*

The yield benefit options of chining the chuck, depending on market values and consequential cut specifications are:

- The dorsal strip remains on the chuck, as opposed being left on the chine with manual fleecing.
- The spine bone meat or the meat between the heads of the ribs remains on the chuck.
- The chuck rib set intercostals can remain on the chuck by scalloped/fleecing the chuck ribs bones off.

The project has demonstrated that mechanised chining of the chuck is possible. And that the yield is in line with what was proposed in (Thomson, 2024).

A standalone chuck chining machine has been proposed, suitable for processing 164 head per hr.

Depending on market value of spine bones, chuck, chuck ribs and trim, the payback could be between 1.1 years and no payback.

If the cube chining machine can be utilised for chuck chining, then improved benefit maybe obtained.

It is recommended that chining chuck capability is considered in the development of the chining cube module.

*Benefits to industry*

The benefit to a processor, and by extrapolation to the industry, is significantly influenced by the market values of spine bones, chuck, chuck rib sets and trim.

*Future research/extension/adoption and recommendations*

It is recommended that chining chuck capability is considered in the development of the chining cube module.

Currently because of the market variability and influence on the benefit, that the commitment to the development of the specific chining chucks module is reviewed with input from a beef processor market review and analysis.

# 3 Introduction

There is an opportunity to automate the removal of the chine bone from the beef bone-in chuck, targeting yield improvement, labour saving and improved operator safety.

This project has focused on addressing the knowledge gaps identified in the previous exploratory project (Thomson, 2024).

The main question was to determine whether mechanised chining of the chuck was practical. And given the achievable accuracy, overall value of the resultant pieces, and the required capital cost, is it economic to develop a viable machine.

The main target audience is the Australasian beef processing industry

The results of the research will form a business case for proposing a prototype machine development project. With the desired outcome being the development of a prototype which will contribute value, by way of yield/improved meat value, labour saving and improved safety, to the Australasian beef industry.

# 4 Project objectives

To develop and trial processing methods for the L4B06 Module – chuck chine bone removal.

Adapt prior learnings from the L4B01 Module – Striploin Chine Bone Removal unit.

Conduct development work at Scott Technology workshop and trialled at site as an extension activity where possible in collaboration (and assistance from) with an Australian processor.

To trial basic materials handling and cutting methodologies.

The success of this project will provide the steering group including Scott with the information required to determine the first stage requirements for development of a L4B06 Chuck chine removal concept and inform LEAP4Beef strategy moving forward.

# 5 Methodology

## 5.1 Background

In previous project the automation of the beef process has been broken up into the modules shown in Figure 1

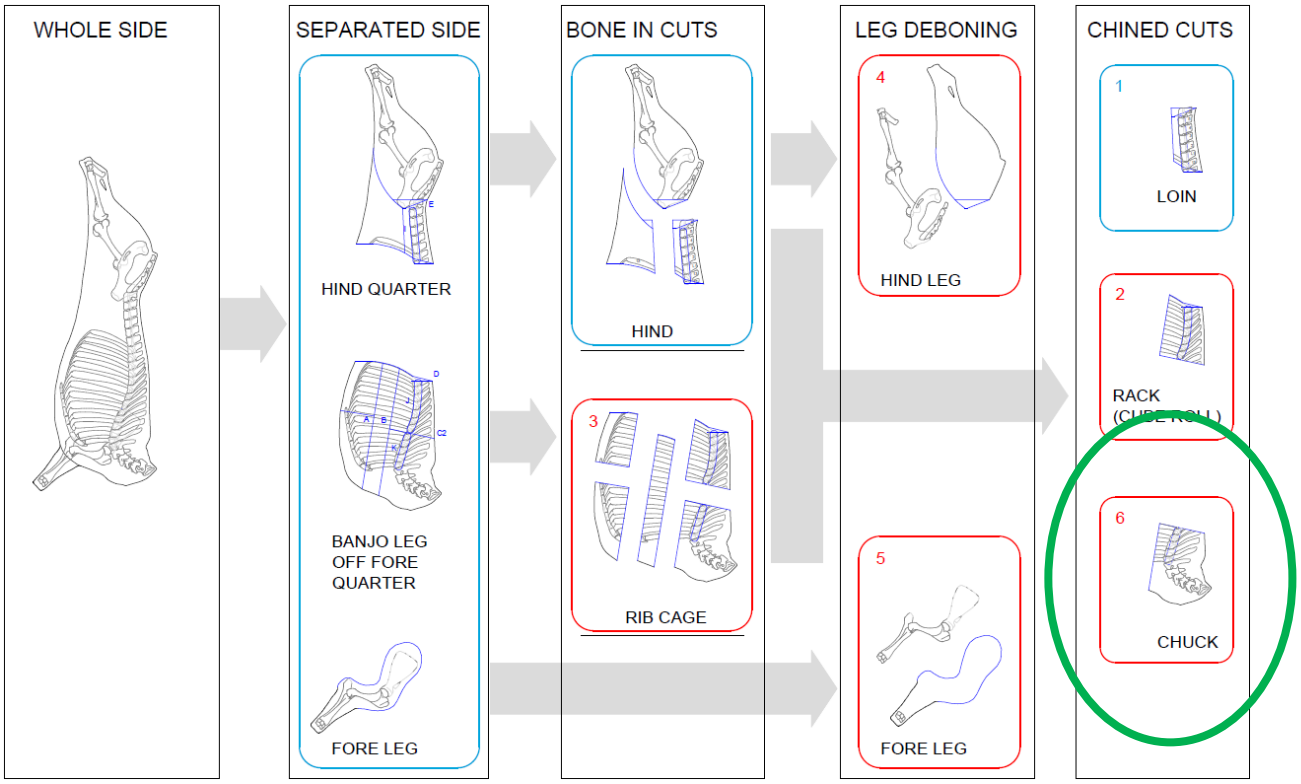



*Figure 1: Proposed beef automation modules*

Where this project is identified as CHINED CUTS, LOIN. (Marked in green)

The modules are:

- Leap 4 Beef Module 01 Striploin chine bone removal
- Leap 4 Beef Module 02 Cube roll chine bone removal
- Leap 4 Beef Module 03 FQ Cuts processing (less banjo)
- Leap 4 Beef Module 04 HQ Leg bone removal from meat
- Leap 4 Beef Module 05 FQ Leg bone removal from meat
- **Leap 4 Beef Module 06 Chuck chine removal**

It was identified in (Thomson, 2024) that there is a significant yield improvement in chining the chuck. Where it is proposed that if the chuck is chined there is a significant portion of meat at the base of the feather bones that would be able to be maintained on the chuck. Location shown in Figure 2.

Scott has done a previous project for chining of a strip loin (Maunsell & McCrorie, 2024). The test rig has been implemented at an Australian processor. However as detailed in this report, the bandsaw is not considered appropriate for chining of the chuck.

The key knowledge gaps are identified below:

| Knowledge gap | Background |
|---|---|
| **Clamping means** | The challenge regarding clamping includes establishing clampable real estate on the product that can be achieved with interference with the cutting means path. |
| **Sensing means** | Scott has the (Maunsell & McCrorie, 2024) camera upgrade project to determine whether external surface scanning can determine the suitably accurate cut path. The sensing means will need to be proposed and validated so that the view of the required features are not excessively compromised. |
| **Cutting means** | Bandsaw, circular saw or alternative. The cutting means selection interacts with the clamping and sensing means. |

Referring to (Thomson, 2024) the benefit is dependent on product selection and current markets.

But this proposed benefit can be significantly impacted by relative prices of current market products, such as trim value relative to chuck, “meaty” bones and chuck ribs.

## 5.2 Literature review

Search relevant research, typically online. Review most relevant work, particularly (Thomson, 2024).

## 5.3 Key metric that drives the business case.

Establish the key metric that drives the business case for the beef processor if the proposed process is implemented. Then establish a model to measure viability for the development of the enabling machine.

## 5.4 Mind map process options and candidate selection evaluation

Propose alternative process strategies and engineering solutions and evaluate performance using the key metric against the formulated business case model

## 5.5 Product & Process Cross sections

Create the relevant cross sections, showing target yield improvement and potential clamping solutions.

## 5.6 Develop test plan and build associated test rig

Establish the “knowledge gaps” and devise a relevant test plan. Develop a test rig that enables the required trials.

### 5.7 Trials through the test rig and establish results.

Establish a run sheet of planned trials, perform the trials and collect the data which enables making a data supported statement, particularly using the key metric.

### 5.8 Concept and estimate price of commercial prototype

Create a concept of a chuck chining machine and establish a “rough order of magnitude” pricing.

### 5.9 Business case estimation

Refine the business case model using the key metric and appropriate inputs for a relevant Australian processor.

## 6 Results

### 6.1 Literature review

The internet, including the European patent office, has been searched.

Key phrases and words used include: *“A carcass processing machine that has bone cutting blades for cutting portions from vertebra of carcass”*

There are various handheld breaking saws which can be used in either the pork or beef industry for chuck, cube or short loin chining. Equipment supplies in this space include:

- Kentmaster
- Freund
- Jarvis.

There various chining means in the lamb processing industry. In the automation space, Scott is the most significant provider. The lamb chining, automatically, is performed with the lamb rack as a saddle. (New Zealand Patent No. AU2013257331A1, 2015-01-28). The beef requirement is to chine, as a split product.

Current market offerings for chining of split sides of pork or beef include:

- Frontmatec smart rib saw; the system utilises a circular saw and 3D ruler sensing (Frontmatec, 2025)
- Midwest machine; the system utilises simple fixtures on a moving conveyor and bandsaws with saw height adaption. (Midwest_Machine, 2025)

Scott earlier work has been reviewed, and it significantly contributes to this project.

Previous Scott work includes:

- (Scott Technology LTD, 2018)
- (Thomson, 2024)

## 6.2 Key metric that drives the business case.

### 6.2.1 Key metric that drives the business case

1. Yield, major economic driver
2. Labour saving, economic and enabling driver
3. Product quality
4. Safety
5. Product food safety compliance
6. Hygiene & associated enhanced product shelf life

## 6.3 Product & Process Cross sections

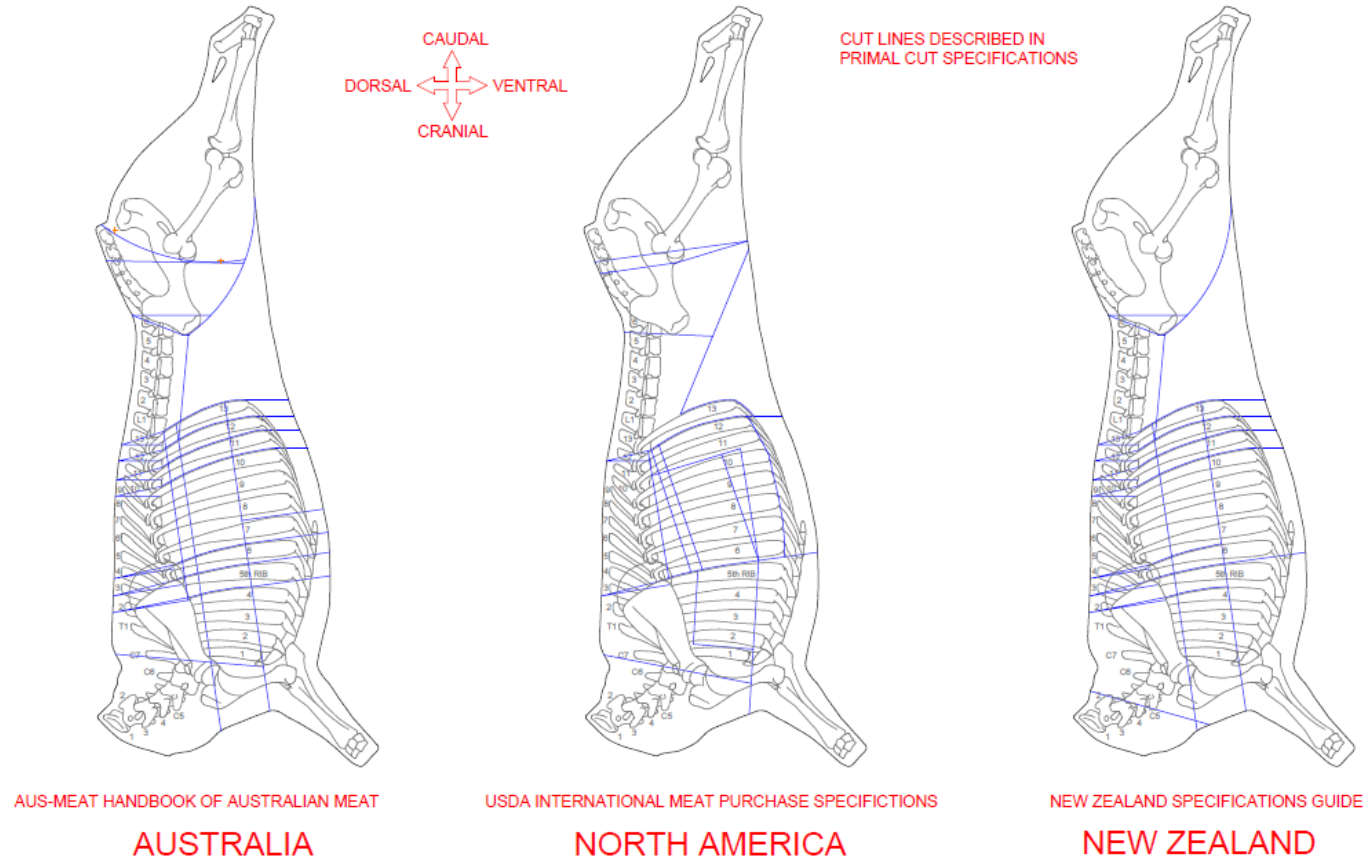



*Figure 2: Industry specifications - by country*

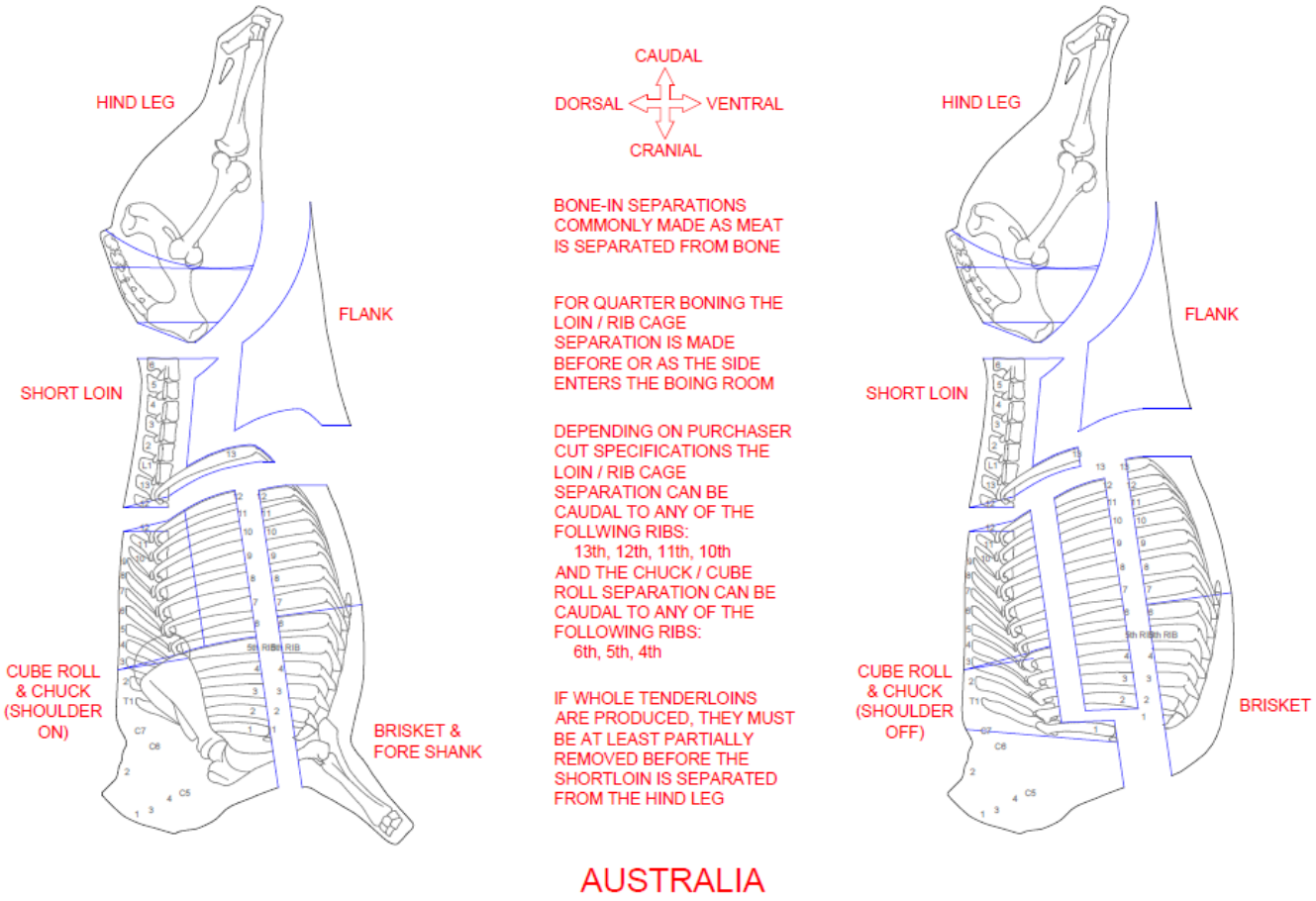



*Figure 3: Specification detail - Australia*

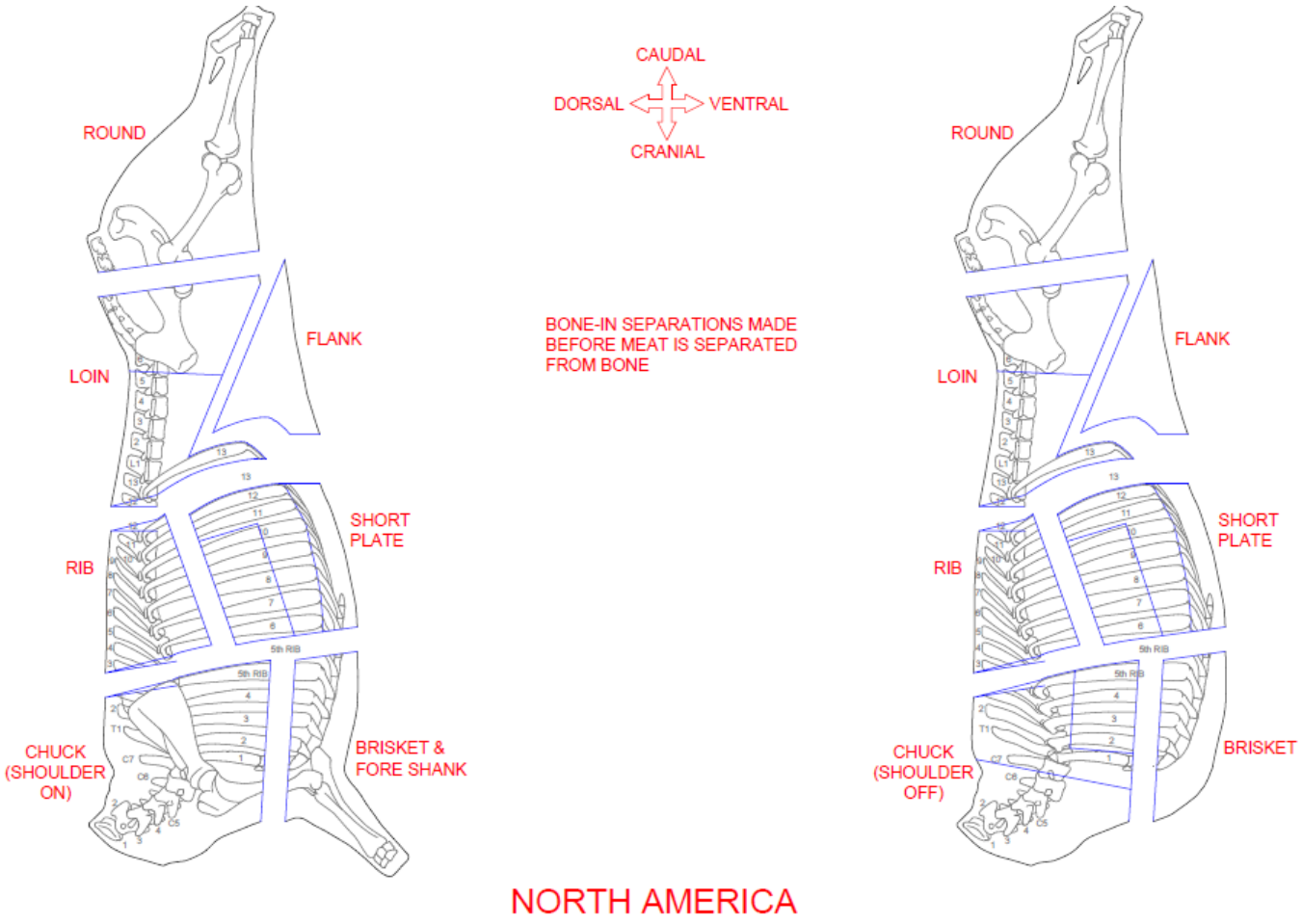



*Figure 4: Specifications in detail - North America*

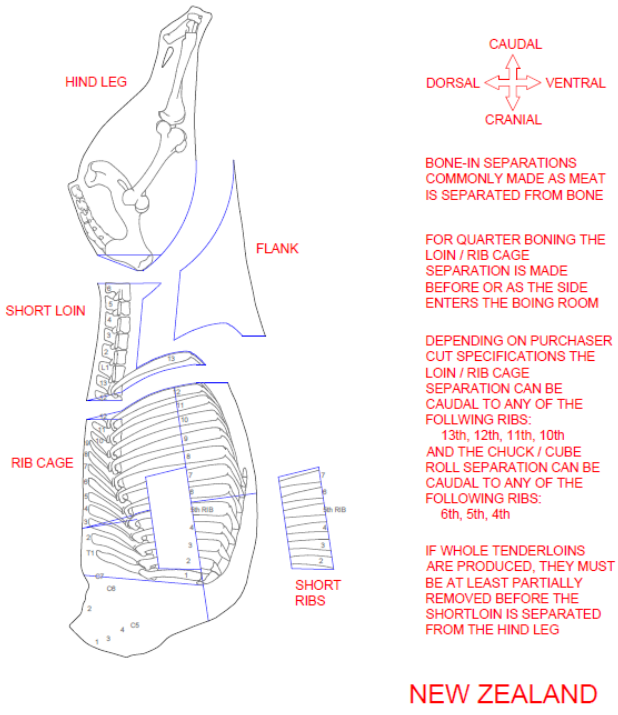


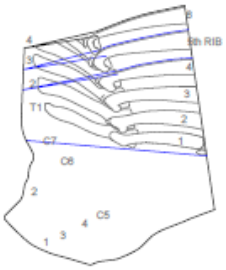

*Figure 5: Specifications detail - New Zealand*

FOR AUS-MEAT 2250 TO 2252

FOR IMPS No.115

BONE-IN PRIMAL FOR BONELESS CHUCK AND BLADE

*Figure 6: bone-in primal for boneless chuck and blade*

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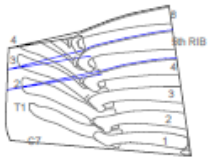


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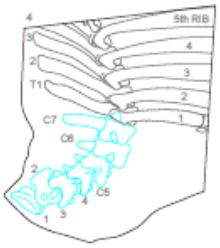


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NECK ON

NECK OFF

BONE-IN PRIMAL FOR BONELESS CHUCK

*Figure 7: Bone-in primal for boneless chuck*


FOR AUS-MEAT 2289


FOR AUS-MEAT 2289


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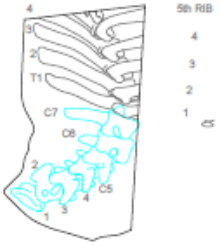


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BONE-IN PRIMAL FOR BONELESS LONG CHUCK ROLL

*Figure 8: Bone-in primal for boneless long chuck roll*


*Figure 9: Beef skeleton showing relevant geometry to chine*

## 6.4 Develop test plan, design and build associated test rig

### 6.4.1 Design of experiment - test plan

#### 6.4.1.1 Overview

In the same way that short loins are chine cut (after tenderloin removal) to improve boneless yield, chucks and cube rolls (or ribs) can also be chine cut to improve boneless yield.

Scott has robotically chine cut cube rolls with a band saw and have manually chine cut chucks with a hand saw. In both situations it can be necessary to compromise the chine cut line to avoid cutting ribs, particularly at the cranial end of bone-in primal pieces.

The aim of chine cutting trials at a local processor is to investigate the feasibility of chine cutting bone-in chucks and cube rolls with a circular saw to avoid rib damage.

#### 6.4.1.2 Experimental method

***Load***

- Isolate the saw
- Lower the clamp to be horizonal
- Load the piece to be cut into the clamp and tighten all clamp
- fingers including those that are empty

***Adjust***

- Set the jig to cut along the chosen chine cut line by adjusting:
    - Clamp angle from horizontal
    - Clamp horizontal position perpendicular to the saw blade
    - Saw blade depth
- Take photos

***Cut***

- Clear the safety area
- De-isolate the saw
- Start video recording
- Start the saw
- Use the long handle on the clamp carriage to move the clamp (with piece to be cut) past the saw
- Stop the saw
- Stop video recording
- Isolate the saw
- Inspect results
- Ready the jig for the next test piece

#### 6.4.1.3 Tests

To establish the following operational aspects the first tests are best conducted using fleeced bone sets.

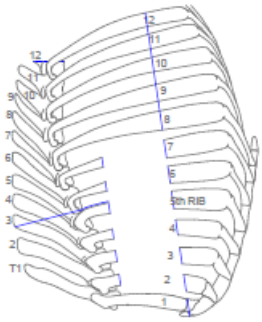
- Is it likely that we can suitably clamp chucks and racks
- Are ribs shortened to the brisket cut line OK, or do we need them shortened to the OP rib / short rib cut line
- Is adjustment best with left (caudal leading) or right (cranial leading) primal pieces
- What cutting discs satisfactorily cut bone

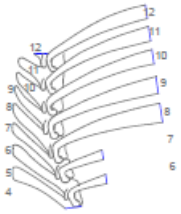
Following satisfactory bone only testing, bone-in primal pieces should be cut. As part of results inspection, chined yield could be compared to non-chined yield of the opposite handed part from the same carcass.

#### 6.4.1.4 Tests

1a) Bone only rib-set including

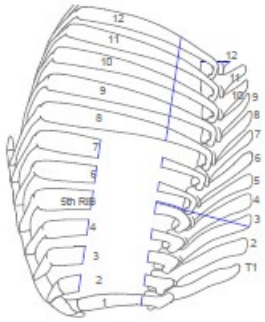
- ribs 6 to 7 trimmed to the dorsal short rib cut line
- ribs 8 to 12 trimmed to the brisket cut line

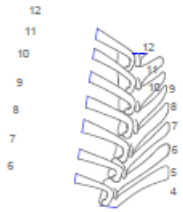



1b) Bone only rib set of opposite hand to test 1

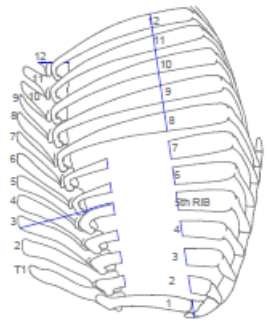
- all ribs trimmed to the short rib cut line

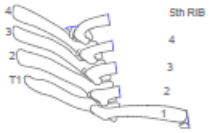



2a) Bone only chuck ribs

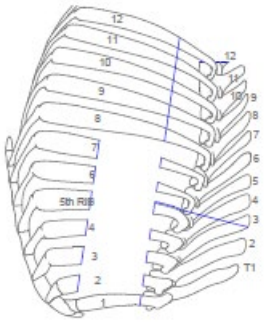
- excluding neck bones
- including ribs 2 to 5 trimmed to the dorsal short rib cut line
- Including rib 1 trimmed to the brisket cut line

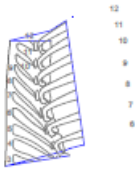


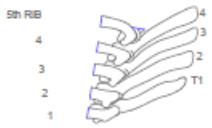




2b) Bone only chuck ribs of opposite hand to test 3

- excluding neck bones
- all ribs trimmed at the dorsal short rib cut line

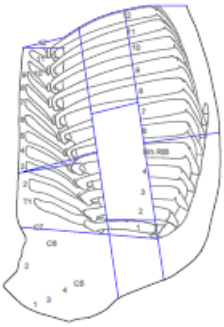





3) Bone in rib set

- Preferred rib length established in tests 1a and 1b (also production dependent)
- Required hand established in tests 1a and 1b

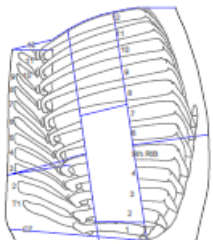


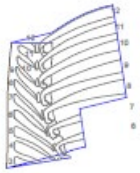
OR

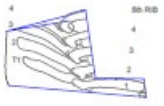
(or opposite hand)

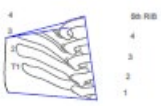
4) Bone in chuck

- Neck bones out
- Neck chain out
- Shoulder off or scapula and humerus out (preferred but production dependent)
- Preferred rib length established in tests 2a and 2b (also production dependent)
- Required hand established in tests 2a and 2b
- Neck on / neck off depends on what we can do without unacceptable damage to the neck (also production dependent)









(or opposite hand)

**It may be necessary to add or repeat tests depending on how testing goes and on what we learn as testing progresses.**

### 6.4.2 Test rig

Clamping

The clamping onto the spine was selected as the preferred solution. For the test rig, a clamp design was utilised that grips the ventral portion of the spine with detail to resist non opposing forces on the split face. A design was developed using the cross section constraints to effect clamping while enabling the circular saw to cut on the optimum path. The cross section was developed on Solidworks 3D CAD and built.

Sensing
Sensing prototyping and trialling was not in this projects scope.

Cutting
The preferred solution is the circular saw. Alternative blades were purchased to provide options regarding teeth profile and diameter.

The CAD model of the developed test rig is shown in Figure 3.

The rest of the test rig included:

- Frame
- Freund cutting head
- Transverse axis
- Electrical cabinet
- Safety controller
- Dead man switch
- Guarding

### 6.4.3 Test run and results

#### 6.4.3.1 Test rig at local processor

The test rig was transported to the local processor and installed in the innovation room with the assistance and support of their staff.

The supplied product was organized as per the test plan.

Fleeced bone sets were used initially for setup and validation of cut path, clamping and cutting. The bone sets were from prime cattle of weight range (hot carcass weight) of 250 – 350kg.

The blade speed was reduced to 50% of nominal speed (50hertz)

The trials were performed on 10$^{th}$ of June 2025.

The “meat” trials were performed on manufacturing grade cattle.

#### 6.4.3.2 Trials and qualitative results

Chuck Yield Improvement by Chine Cutting

To produce all boneless chuck specifications, chuck meat is fleeced from the appropriate part of a rib cage, or the rib cage is fleeced from the chuck meat.

Because of bone shapes at the rib heads, it isn't possible to economically fleece chuck meat off bones in one piece in a way that leaves all the bones clean.

Meat value is typically recovered from fleeced chuck bones in three areas.

*Figure 10; Chuck spine bone with ribs and feather bones removed*

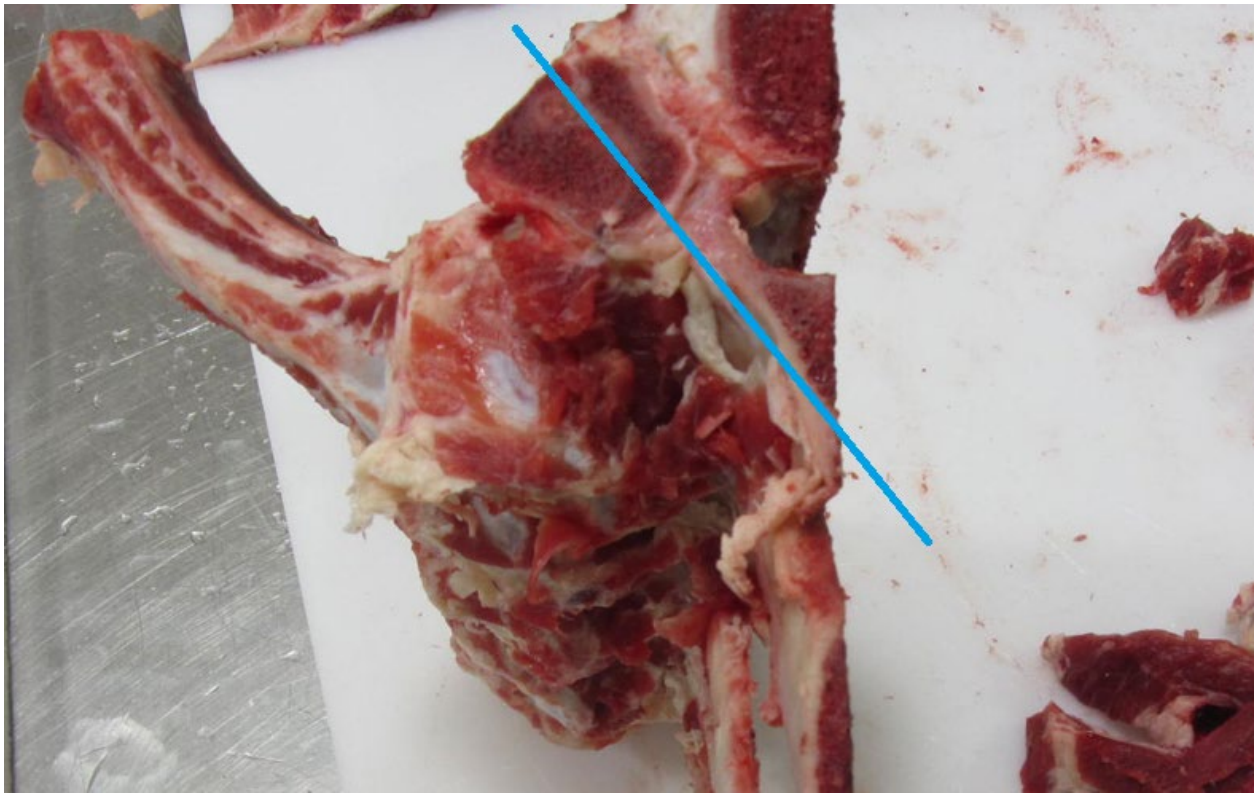


*Figure 11: Chuck chine cut line*

The chuck bones in Figure 20 show that because the first rib is parallel to the carcass halving plane at its dorsal end and is closer to the carcass halving plane at its ventral end, the chine cut needs to be a blind cut of the correct depth to avoid damage to the first rib and associated meat.

With meat on the chuck bones, correct chine cut placement is more difficult to achieve but is not impossible as demonstrated in Figure 22. To chine a chuck roll with neck on (and neck bones removed) the neck meat must be held out of the cut path.

*Figure 12: Chined chuck roll*

## 6.5 Concept and estimate price of commercial prototype

It is proposed that the preferred concept for a commercial machine would consist of:

- Infeed conveyor to the operator (if machine can be placed on an existing striploin belt – this could be deleted)
- Manually lift chuck into clamp
- Safety means – probably a pull-down door
- Product, in clamp transfers through the saw.
- Product eject means and product outfeed belt.
- On machine Perspex doors for guarding – standalone strategy.
- 11 second cycle time (327 sides per min (164 head per hr))

For further payback, depending on production rate the chuck chining process could be combined with the cube chining process utilizing the same machine.

### 6.5.1 Determination of yield gains and other benefits for the return on investment calculation

The project has demonstrated that mechanised chining of the chuck is possible. And that the yield is in line with what was proposed in (Thomson, 2024).

## 6.6 Business case estimation

Therefore, the expected return is as per (Thomson, 2024). Which stated that the return depends on whether or not there are markets for spine-bones and / or chuck-ribs. If there is no market for either, the chuck bones have a trim and rendering value.

Depending on market value of spine bones, chuck, chuck ribs and trim, there could be a payback of 1.1 years. For example current trim value exceeds chuck value, which negates all benefit of chuck chining.

It is recommended that beef processor market review and analysis is performed before committing to the development of a specific chuck chining machine.

# 7 Discussion

The knowledge gaps, with regard to providing information to inform the steering group regarding the benefit of the chuck chining module have been broken down to clamping, sensing and cutting. With benefit determination being the overriding metric.

## 7.1 Clamping

Clamping is leveraged off clamps developed in (Maunsell & McCrorie, 2024). And given the geometry at the chuck, a clamp arrangement with a very narrow profile has been proposed. The findings include:

**Product Mass:** The beef sections are heavy, requiring controlled support throughout the cutting process.

Resulted in the spine pivoting out of the blade's path due to cantilevered weight.

Clamping Performance: The clamp securely held the product, with no slippage observed.

Modifications: One clamp finger was shortened by 10 mm to enable chuck clamping.

Other: The neck meat, if present, falls in the way for the test jig format. Benefit implications of removing the neck meat before the chining process should be reviewed. Else meat support or product orientation would need to be considered in the prototype.

## 7.2 Analysis strategies

Conventional: Conventional vision analysis strategies incorporate tools such as transformations and determinations using thresholds to give definitive outputs.

The differences from the short loin project and associated risks to address include:

**Precision requirement:** A departure from the ideal cut surface by more than 5mm, can prevent the access for the knife work need to release the meat that is the beneficial yield.

**Visibility:** The views for the vision system may be compromised, particularly the cranial end and, if present, effect of the neck meat.

## 7.3 Cutting

The knowledge gap regarding cutting is about the cut surface location, the available depth and the force on clamps and associated slippage and accuracy loss.

**Future optimisation:** Reduce saw dust and meat smearing.

## 7.4 Activities, project outputs/deliverables and objectives

Aligned with the “knowledge gaps”, a test rig was developed at Scott Technology workshop. “Dry” trials and associated improvements made to resolve issues before introducing meat and boning room constraints. There have been fortnightly meetings with an Australian processor to support the activities. The actual trials were performed at a local processor innovation room. The access to knowledgeable staff and product, pre-worked appropriately, was of significant benefit to cost effectively progressing the development.

Basic materials handling and cutting methodologies, including clamping, alignment, depth and alternative saw blades.

Testing and demonstration included:

- The product and the outputs were photographed, with particular focus on where the meat able to be recovered versus when fleeced manually.
- Products supplied were of variable sizes. The scope does not constitute an establishment of product size limits.
- The trials were videoed.
- In this case the project demonstrated that mechanised chining of a chuck was possible. The weight measurements were inferred by referring to the artificially manually created and measured chuck chining in (Thomson, 2024). Analysis of potential yield, and associated impact from the market value of the various products, leveraged off the methodology in (Thomson, 2024).

Representatives from AMPC, MLA and the engaged Australian processor were welcome to view the trials.

Regarding the LEAP4Beef automation strategy, the work in this project is establishing the viability of chucking chines, and the potential of a Leap 4 Beef Module 06 Chuck chine removal module. Which would feed into subsequent decisions to develop standalone and/or subsequent integrated systems.

### 7.5 Standalone chuck chining machine.

A standalone chuck chining machine has been proposed, suitable for processing 164 head per hr.

### 7.6 Business case

Depending on market value of spine bones, chuck, chuck ribs and trim, the payback could be between 1.1 years and no payback.

If the cube chining machine can be utilised for chuck chining then improved benefit maybe obtained.

It is recommended that chining chuck capability is considered in the development of the chining cube module. Currently chining chucks, because of the market variability and influence on the benefit, that development of the specific chining chucks module is not justified.

## 8 Conclusions

The project has demonstrated that mechanised chining of the chuck is possible. And that the yield is in line with what was proposed in (Thomson, 2024).

A standalone chuck chining machine has been proposed, suitable for processing 164 head per hr.

Depending on market value of spine bones, chuck, chuck ribs and trim, the payback could be between 1.1 years and no payback.

If the cube chining machine can be utilised for chuck chining, then improved benefit maybe obtained.

It is recommended that chining chuck capability is considered in the development of the chining cube module.

Currently because of the market variability and influence on the benefit, that the commitment to the development of the specific chining chucks module is reviewed with input from a beef processor market review and analysis.

## 9 Recommendations

It is recommended that chining chuck capability is considered in the development of the chining cube module.

Currently because of the market variability and influence on the benefit, that the commitment to the development of the specific chining chucks module is reviewed with input from a beef processor market review and analysis.

# 10 Project outputs

Outputs (tangible deliverables) delivered during the project include:

- Technical reports for milestone 1, summarising options evaluated, results from trials and recommended future paths of research
- Data has been collected for the various research, alternative solution evaluation and experimental activities and analysis performed. Presented in the technical reports in various tabular and graphical formats.
- The test rig utilised is in storage at Scott Technology.

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# 12 Appendices

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