final report

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Waterless french rack processing feasibility

Stage 1

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Executive summary

After performing various experiments on five different methods, the final method provided sufficient evidence that it is possible to develop a commercially viable French racking solution that performs the frenching mechanically, which is subject to the following:

1. Product is fresh (consumable state)
2. Able to know location of rib on rack to perform scribing
3. Scribing must be on both sided of the rack and sufficiently performed

As shown by many attempts over the past 10-15 years by other researches the use of mechanical scrappers to ‘drag’ the meat from racks (methods 1 and 2) is not viable due to the non-uniformity of the ribs locations, spacing’s, diameters and profiles.

Option 3, using a combination of pre-cutting and force still required the Frenched bones to be cleaned, and the use of CO2 or compressed air although having some merit did not seem like a commercially viable long term approach.

The research and experimental work undertaken with fresh product under methods four and five, suggests that in order to make this frenching successful by mechanical means, it is imperative to ensure good clamping on either side of the rib and to pierce the membrane on top using a sharp pin to subsequently rip the rib from the membrane.

It is proposed that as a result RTL and MLA undertake a Stage 2 project to build a working mechanical prototype that will demonstrate Frenching mechanically in an RTL production R&D facility.

Contents

1 Project Background

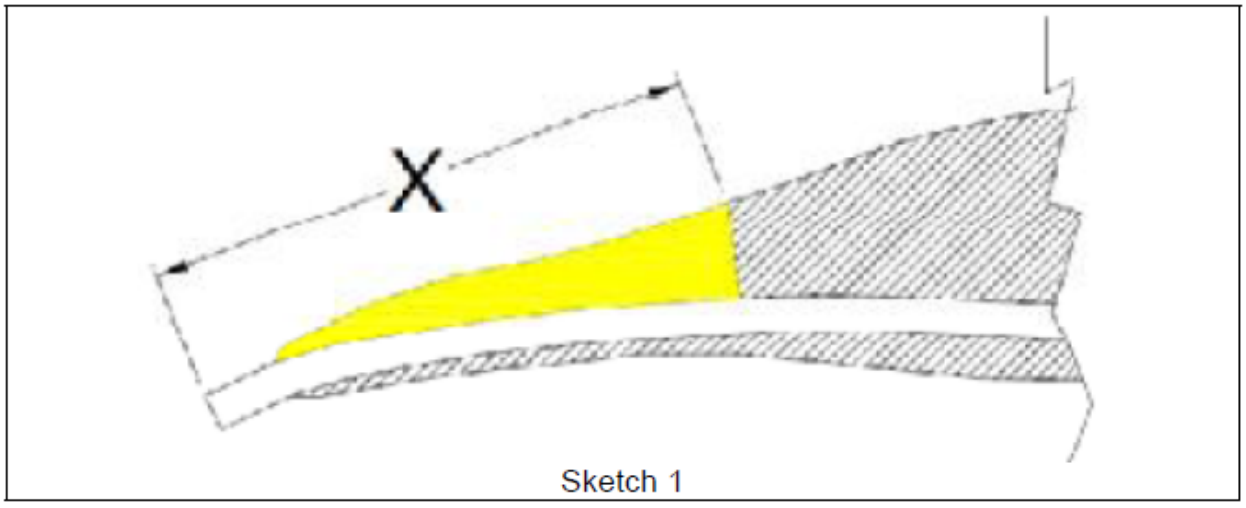
Through a process of consultation with MLA and Australian Smallstock processors via the MLA organised “Australian Sheep Processing Automated Boning Room Steering Committee”, the Australian processors voiced their desire to place priority on developing a fully automated waterless Frenching machine.

Hence the purpose of this Stage 1 project was to test various mechanical concepts to automate lamb French racking. Ideally it was anticipated that at the conclusion of Stage 1, a preferred option would be identified and the Committee and MLA would support RTL in developing a working prototype under a Stage 2 project.

The solution proposed had to be able to function (and be commercially viable) as both a standalone unit and also as part of an integrated item within the Leap IV middle processing system being developed by RTL.

2 Product Specification Targeted

To contain the focus of concepts investigated, RTL only considered concepts and tested them against a specification of a cap on rack, removing (Frenching) the material shown in yellow in Sketch 1. The distance X can vary from 25-75mm.



Sketch 1

The best solution will result in the removal of the intercostals and present a finished product in the form as depicted in Picture 2 (with cap on)

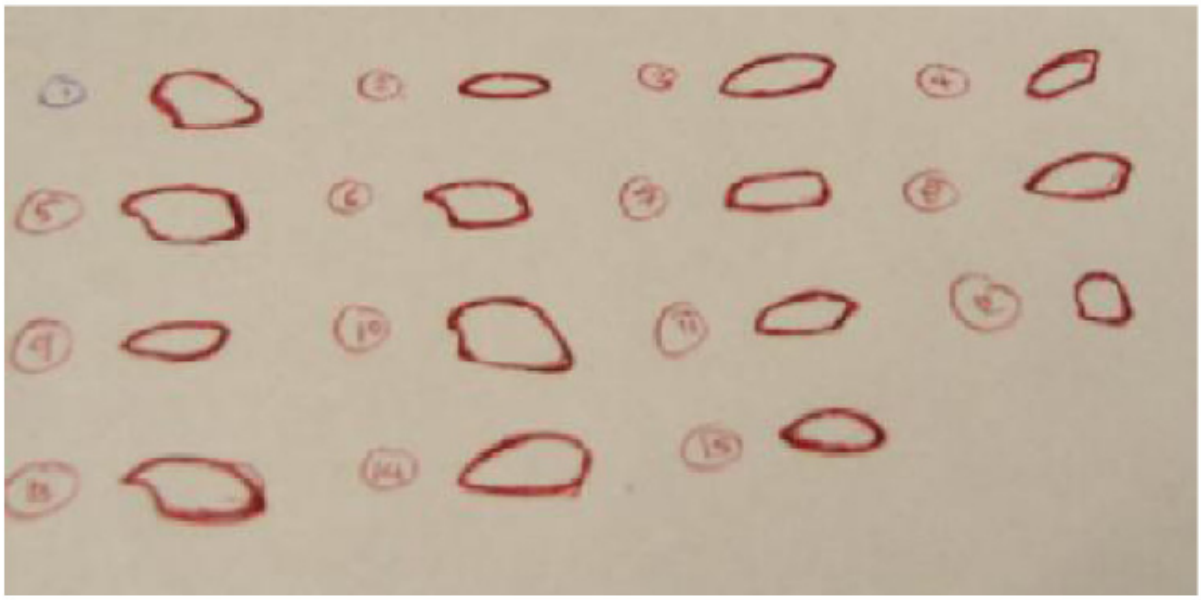
Picture 2

The machine specifications in the final commercial machine that were used when considering possible solutions were:

- 20 Frenched racks per minute throughput (i.e. 10 carcasses per minute)
- Intercostal meat to be retrieved as a saleable product
- Designed to suit stainless steel manufacture
- Full wash down and chemical cleaning

3 Product Variability

A study was made on the profile of the stripped ribs. Sketched in Picture 3 are the



Picture 3

profiles of rib bones that depict a large range of variability.

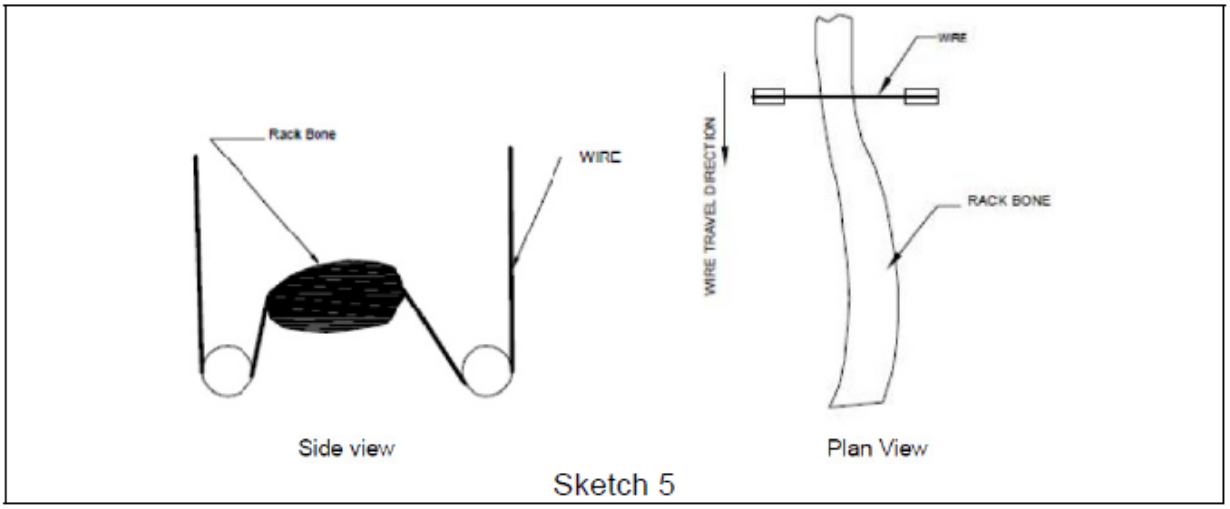
Picture 4 depicts the variability in bone rib profile, showing high variability along the length of the bone.

Picture 4

These variation indicates that a non-rigid (compared with an evenly spaced and fixed trajectory) was likely to be a successful approach to waterless Frenching.

4 Method 1 – Mechanical Scraping (Stationary)

To prove the previous point, RTL developers utilised a fixture made of fine wire (Ø 0.25mm) as depicted in Sketch 5. The wire was wrapped over one half of the bone surface and dragged. Unfortunately the wire slid over the meat rather than resulting in a Frenching action.

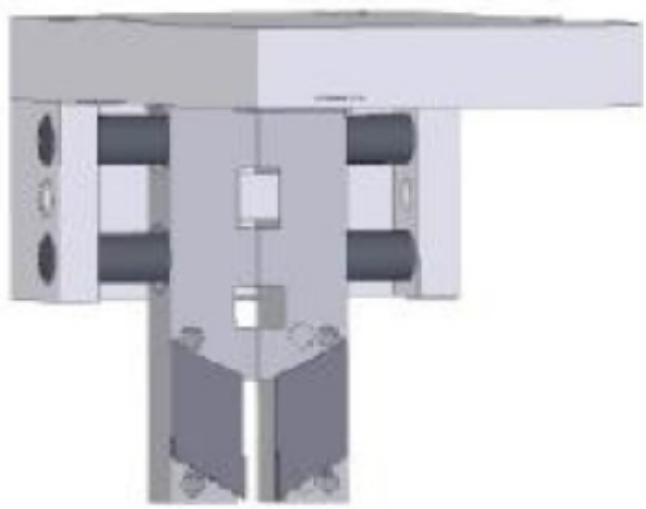


Sketch 5

To enable this concept to have a better chance of working, the wire has to have an oscillating cutting action and the wire needs to be abrasive type. It could be made of fibrous material or a diamond coated which can be purchased of the shelf. Oscillating speed has to be about 15m/s which would relate to about 15,000rpm on a 20mm pulley. However due to the nature of the observed profiles of the bones, some of the meat would still be sticking on some of the bones in areas where the wire would not have access to.

5 Method 2 – Mechanical Scraping (Oscillating)

The second method used a fixture with blades fixed on 2 sides. The intention was to have the blades scraping the meat out of the bones. Picture 6 below shows the concept.



Picture 6

The model above shows 2 blades. A third was fixed on top. Again due to the nature of the profile of the rack bones, this method does not work as it slides on the meat leaving much of the meat on the bone. The pictures 7 & 8 below show an attempt to do this.

Picture 7

Picture 8

Based on the above 2 methods, the primary issue is the removal of the membrane that is attached to the bone while the meat is solidly attached to the membrane.

5.1 Analysis (Method 1 & 2)

Whatever method is approached, the membrane has to be cut and removed from the bone to have a clean bone. Water jet suits the nature of the bones and the other alternative will be to use high pressure gas (air or CO2) with the possibility of introducing abrasive material. However it is understood that the use of water is strictly prohibited

6 Method 3 – Membrane cutting plus force

Step 1

First the cap was cut at the distance X (as in sketch 1 in page 1) using a knife. The knife as it cuts through the cap will have to cut or puncture the intercostals as in the picture 9 below

Picture 9

Step 2 **- Remove the cap:**

Fork Method	**Pull Method**
A fabricated fork was placed at cut section and pull with shearing effect, however the jagged nature of the end product ensures we cannot pulled the cap away (Pictures10, 11 & 12 below show this attempt)	Pull upwards (peel off) from the rack tip end. This eliminates shearing resistance. Pictures 13 & 14 depict the process.
 Picture 10	 Picture 13
 Picture 11	 Picture 14
 Picture 12	
The jagged nature of the end product ensures that the cap cannot be pulled away and the method in the second column was evaluated.	

Step 3
Using a “router/ jig saw principle” or an oscillating knife to cut off intercostals. Using this method, the following pictures 15-22 inclusive illustrate the achievable end effects


Picture 15


Picture 16


Picture 17


Picture 18


Picture 19


Picture 20


Picture 21


Picture 22

Step 4
Remove the intercostals as shown in Pictures 23 – 28 inclusive


Picture 23


Picture 24


Picture 25


Picture 26


Picture 27


Picture 28

The remaining cap is very easily peeled off and the intercostals come off with ease by peeling from the fat area.

Step 5
Next it is suggested to use high pressure jet (air with/without abrasive or CO2) to perform final cleaning.
An attempt to use shop floor air to blast off the remaining material on the bone - these are illustrated in the pictures 29 – 32 inclusive below:


Picture 29


Picture 30


Picture 31

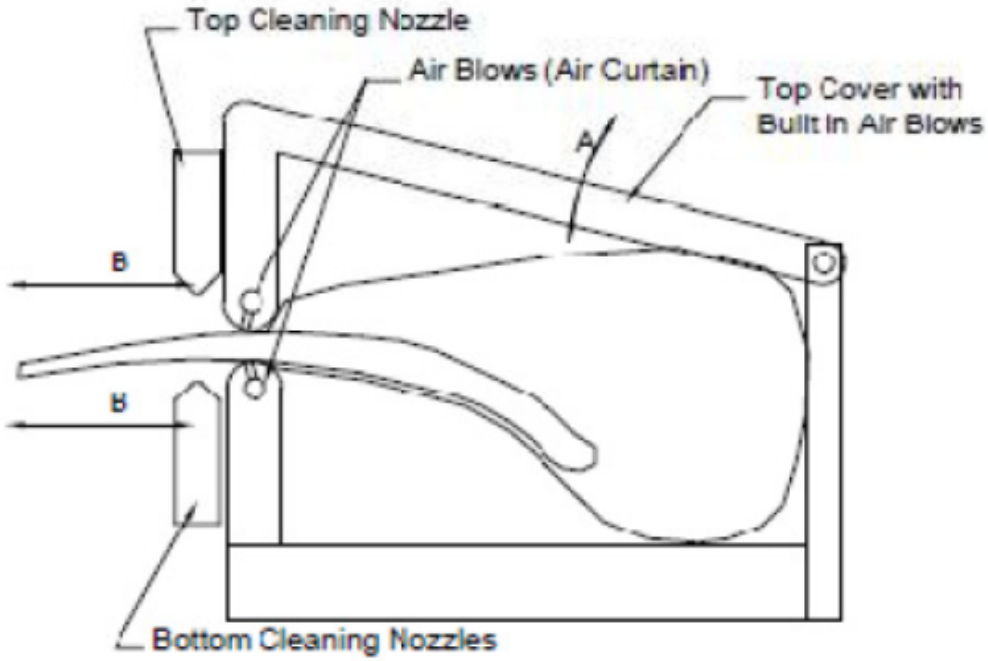

Picture 32

The router/jig saw type system needs to be designed and built.
Much study needs to be undertaken on the high pressure air jet system. Ideally RTL would need either to build or purchase a supersonic nozzle.
If using shop air does not work, the following could be evaluated:

Dry Ice Blasting.

Use soda (sodium bicarbonate) or Corn cob/ walnut shell as media (both of this might not be economically viable).

Concept for the cleaning is as outlined in the sketch 33 below:



Sketch 33

- Product is placed in the fixture while the top cover is in open position (top cover is hinged at one side)
- Air nozzles are built in on the bottom fixture as well as the top cover as shown. Purpose of this is to work as an air curtain to prevent whatever media used for cleaning is prevented from reaching the product.
- Cover is activated to clamp and partially seal the product (cover swings in the direction A)
- Cleaning is performed by the media as the nozzles travels along the direction B as well as in a direction normal to direction B.

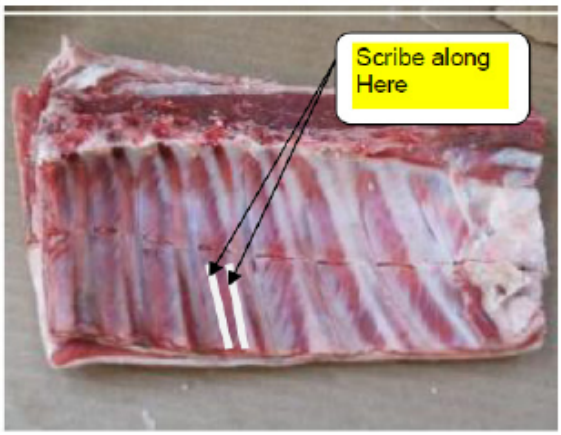
Note:

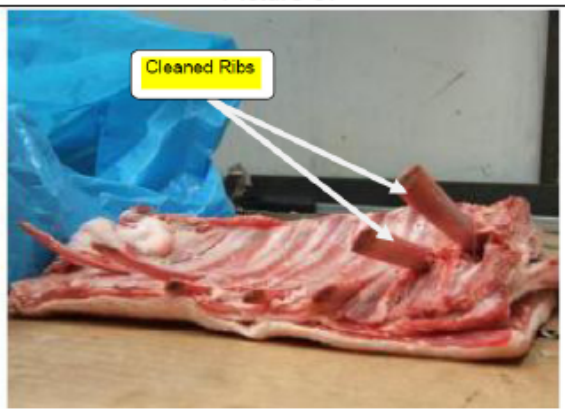
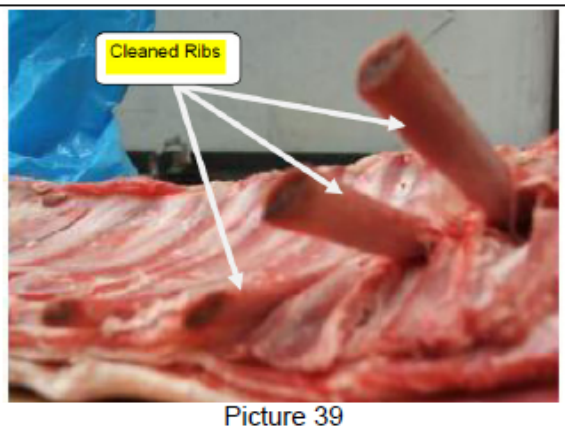
I) The cleaning nozzles can be enclosed in a concealed box as well to prevent media flying everywhere.

II) Venturi type suction can be placed at the bottom to suck out the media and waste.

7 Method 4 – Cutting the membrane and pushing the bone out (Manual)

The steps below illustrate this method.

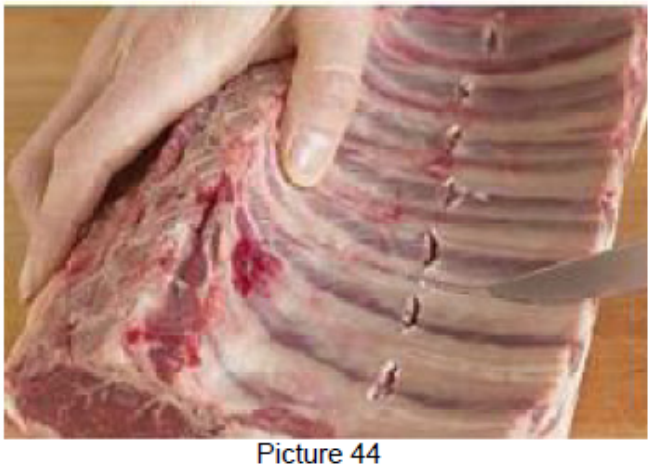
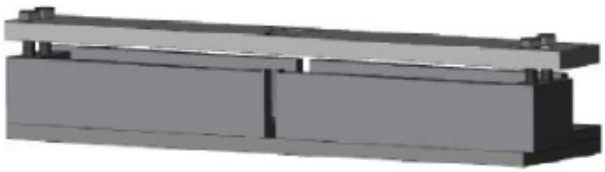
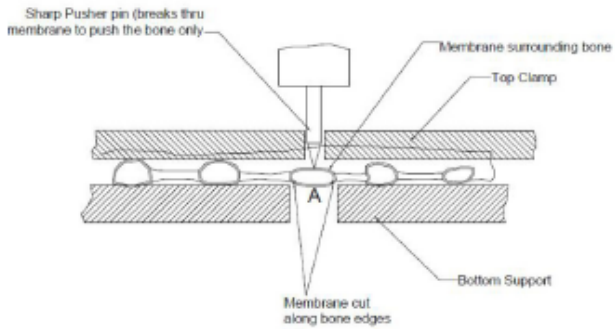
Step 1: Cut lengthwise on the flap	 Picture 34
Step 2: Cut through the intercostals	 Picture 35
Step 3: Scribe along the edges of the bone to cut through the membrane	 Picture 36

Step 4: Use a knife to roll out the silver skin (not cutting through)	 Picture 37
Pictures 38/39 illustrates the outcome of this process	 Picture 38
	 Picture 39
Step 5: Pull out the cap	 Picture 40

	 Picture 41
	 Picture 42
	 Picture 43

8 Method 5 – Cutting the membrane and pushing the bone out (Automatic - simulated)

The above process was conducted manually. Feasibility to do the above process automatically is the basis of this process B. The following were the steps taken to do this.

Step 1: First cut the cap at the distance X (as was described in sketch 1 previously) using a spring loaded knife. The knife as it cuts through the cap will have to cut or puncture the intercostals as in the picture 44.	 Picture 44
Step 2: Reverse the product and cut along the edges of the rib bones.	
Step 3: Clamp the product in the fixture as shown in picture 45	 Picture 45
Step 4: Use a sharp pin to push the bone away (rip off) from the membrane	 Picture 46

The attempt here is to clamp the bones leaving the bone marked A to be pushed through the slot. Prior to pushing the bone with the sharp pin, the bone A is scribed along the edges as indicated earlier. Most importantly is the requirement to puncture the membrane prior to pushing the rib through.

Observations:

The first 2 trials showed some potential of this method. 1 bone came out very clean and the other had some silver skin still attached to the bone on the edges. The pictures 47/48/49 & 50 below illustrates this.

8.1 Trials with New Fixture (14th September 2009)

Picture 47

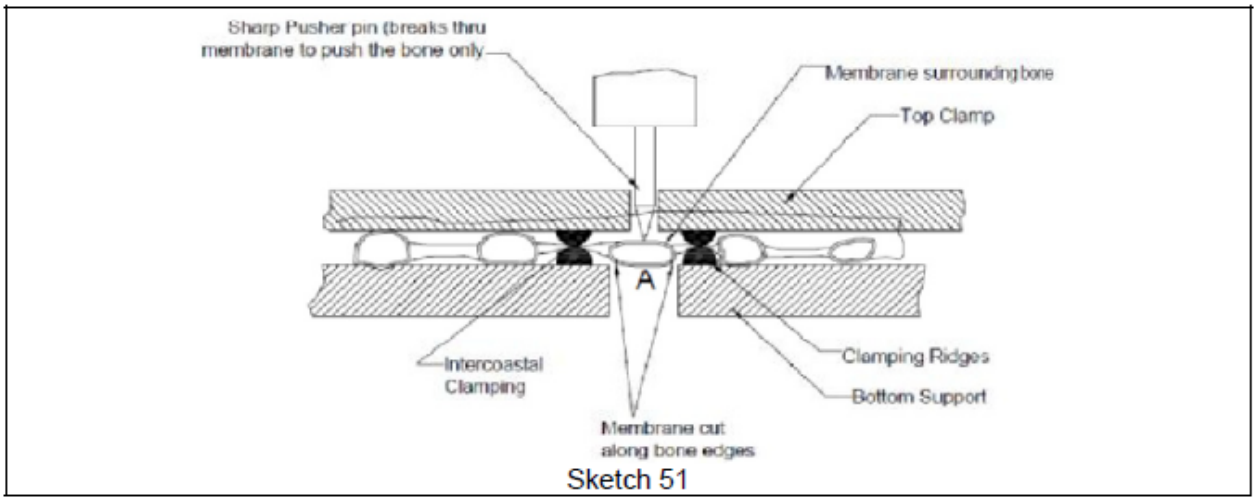
Picture 48

Picture 49

Picture 50

Subsequent trials did not go well as the fat was dragged together with the bone. Manual removal of the material from the bones was found to be very difficult as well. We found the product had deteriorated very badly and the problems faced could be due to this product deterioration. Another highly possible reason will be due to the different bone sizes causing inefficient clamping. The bone A in some cases were found floating within the clamped section.

The next course of action was to ensure the clamping is on the intercostals adjacent to the bone that needs to be ripped off by placing ridges as shown in the sketch 51 below.



Sketch 51

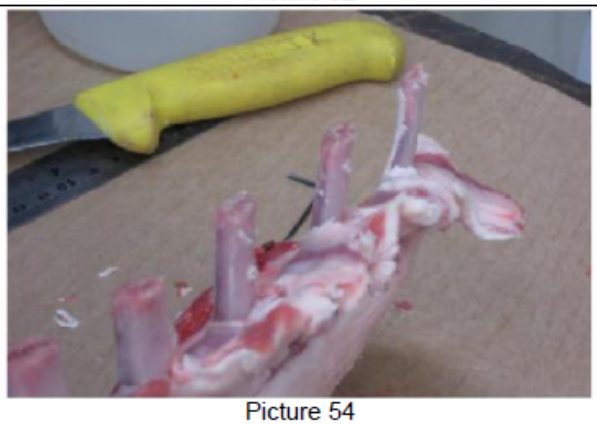
The option of using fine wires to cut the membrane and scrapping across the ribs will continue to be looked into. This involves looking at the possibilities of using oscillating abrasive wires.
At the moment, potential frenching methods are looked into and the issue of cycle time while is important, will only be addressed once the most suitable method is proved
Described below are further trails using fresh product

8.2 Trials performed (24th September 2009)

Trials were repeated using fresh racks and via clamping areas adjacent to the bones. Pictures 52 - 62 inclusive below illustrates the outcome which were encouraging


Picture 52


Picture 53

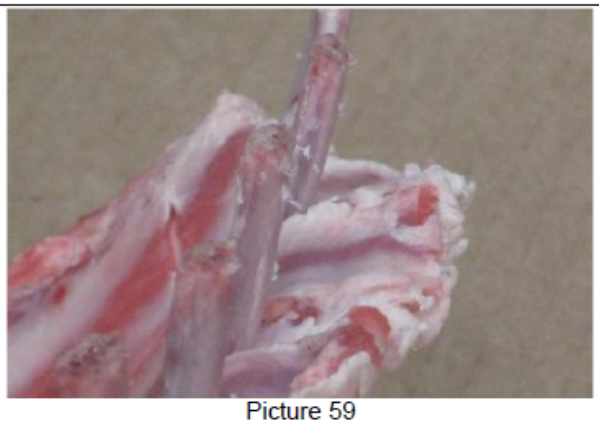

Picture 54


Picture 55


Picture 56


Picture 57


Picture 58

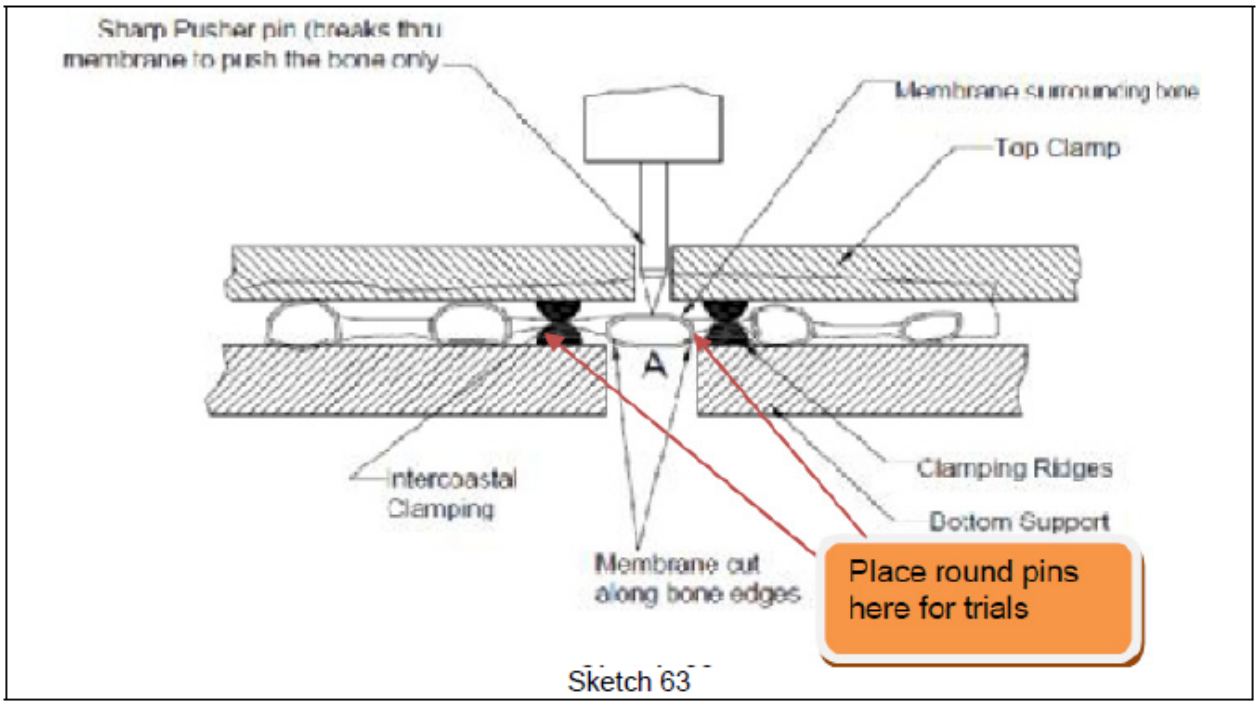

Picture 59


Picture 60


Picture 61

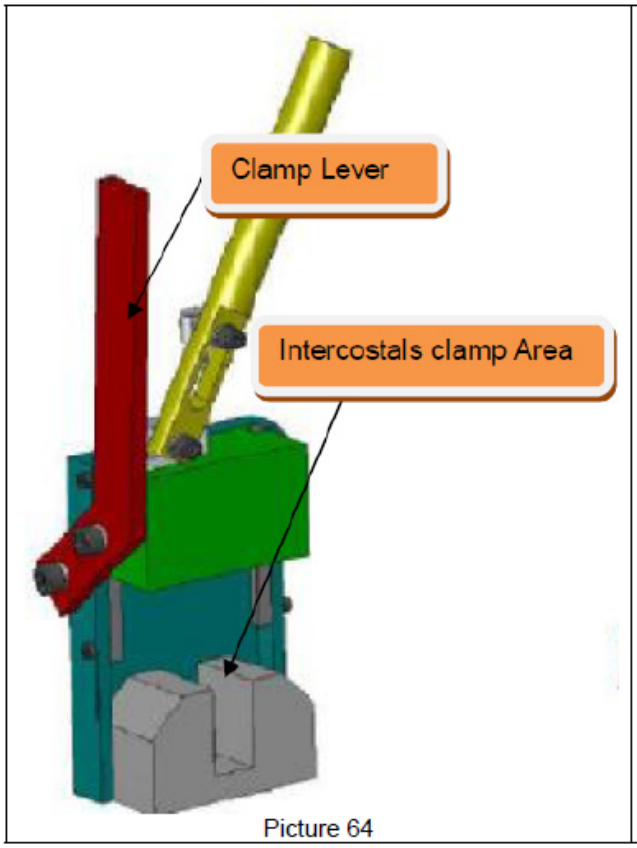

Picture 62

The trials as illustrated in the pictures 52~62 we done by using fresh product and showed improvements for the intercostals clamping. 2 pins were placed on the either side of the intercostals to provide localised clamping on either side of the rib as described in the sketch 63 below:

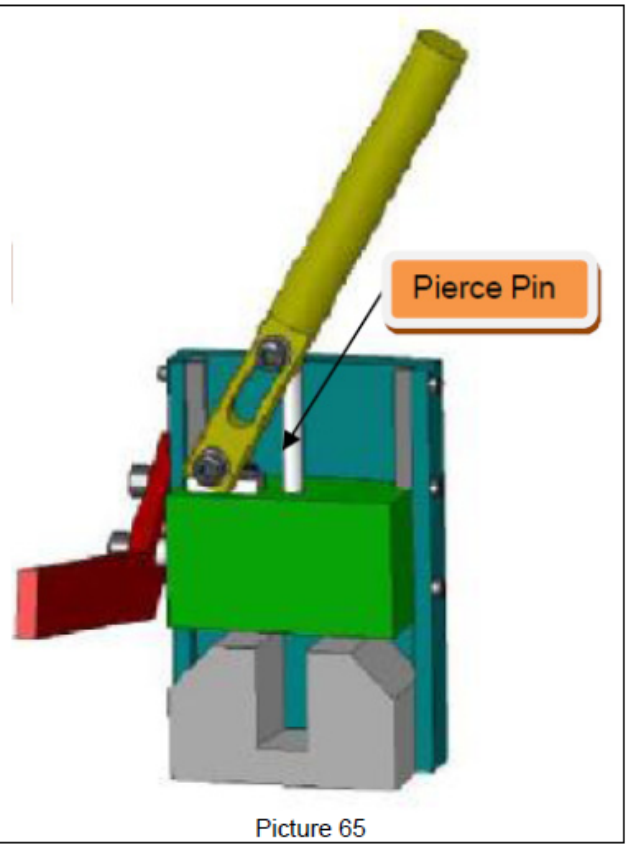


Sketch 63

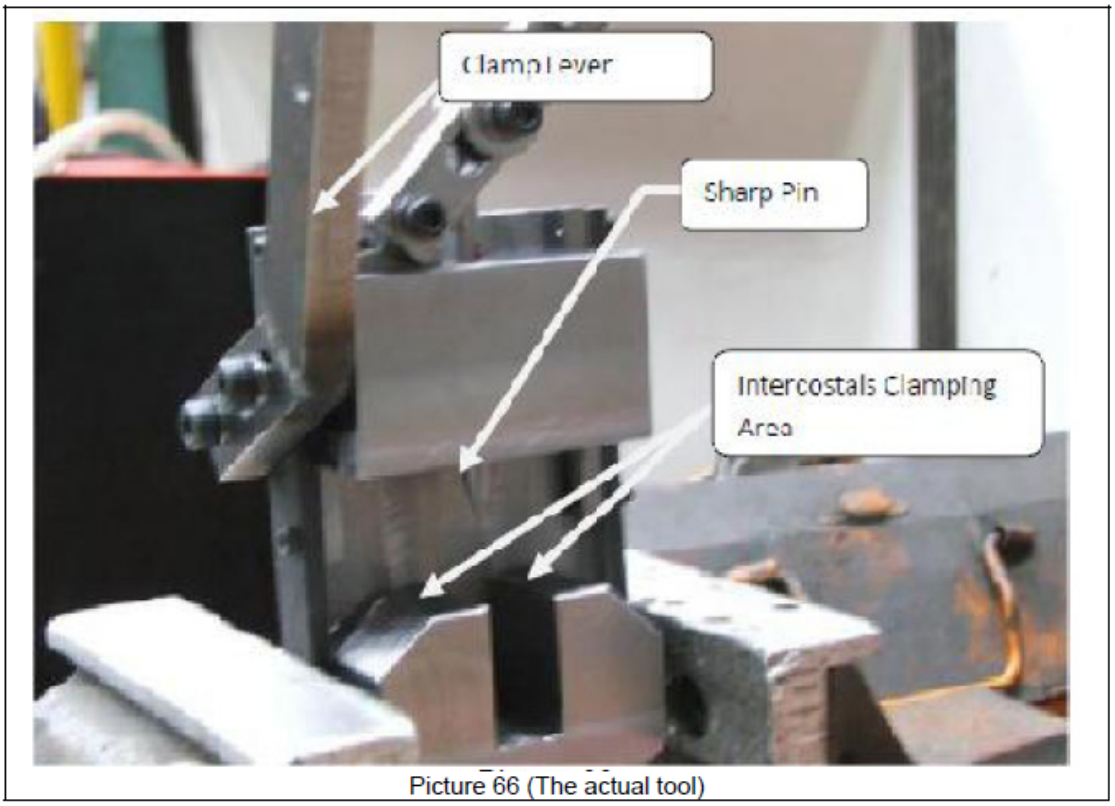
The experiment suggests that in order to make this frenching successful by mechanical means, it is imperative to ensure good clamping on either side of the rib and pierce the membrane on top using a sharp pin and the pin subsequently rips the rib from the membrane. A small tool (Punch/stripper concept) was designed and built to proof the concept as will be explained on the next page.



Picture 64

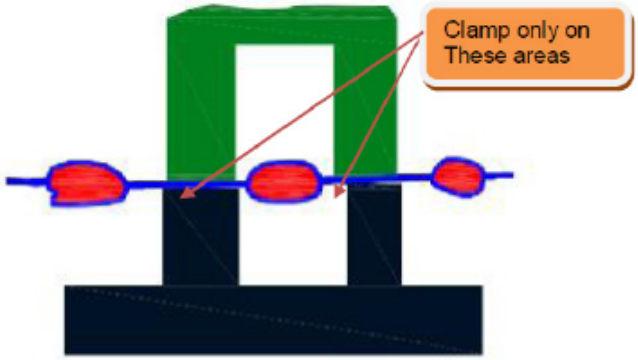


Picture 65

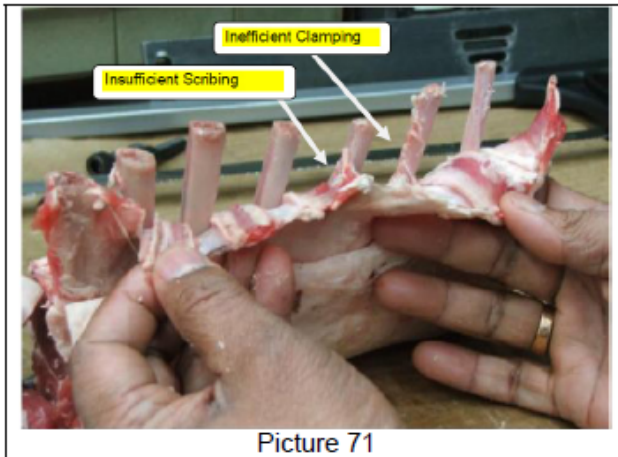


Picture 66 (The actual tool)

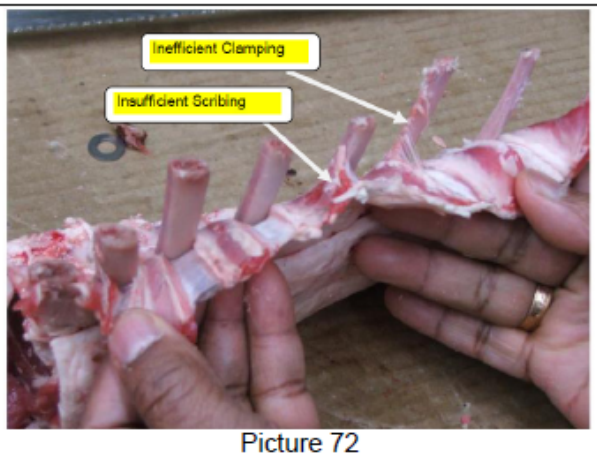
Process description:

Step 1: Place the product onto the clamp area ensuring the rib to be processed lies in the slot and the 2 immediate ribs adjacent to it are outside the clamping area. This is to ensure that the clamping happens only on the intercostals area	 Picture 67
	 Picture 68
Step 2: Clamp down the product using the clamp lever (picture 64) as shown in Picture 69	 Picture 69
Step 3: Use the other pin actuation arm to pierce and rip rib from the silver skin	 Picture 70

Pictures 71 – 76 inclusive, along with some observation notes, illustrates subsequent processing of the other ribs on the rack:

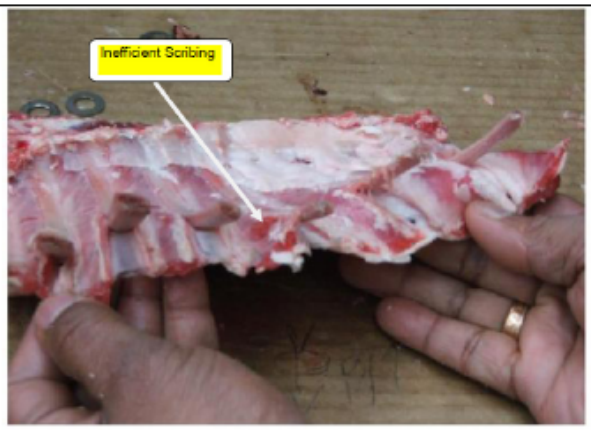


Picture 71



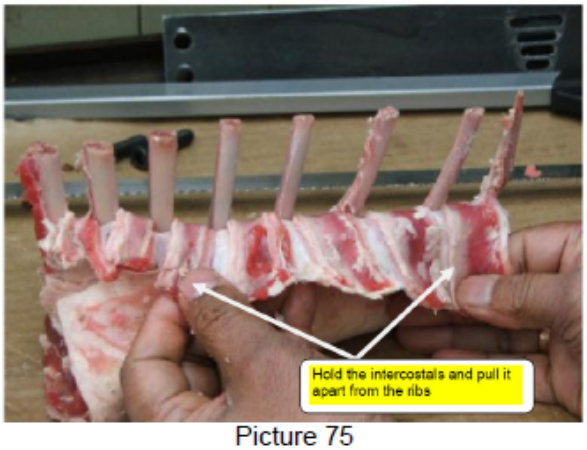
Picture 72

Picture 73



Picture 74

Upon frenching the beginning portion of the rack, the intercostals were held in hand and pulled away from the ribs manually by gripping the whole length with little effort. Pictures 75 and 76 shows these outcomes



Picture 75


Picture 76

9 Conclusion:

After undertaking the various experiments, the final process provides sufficient evident that it is possible to perform the frenching mechanically subject to the following:

- Product has to be fresh (consumable state)
- Able to know location of rib on rack to perform scribing
- Scribing must be on both sided of the rack and sufficiently performed Concepts for possible automation solutions will be provided next.