final report

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Pre-rigor manipulation to enhance meat quality

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Abstract

The current research is primarily to address a final design consideration for direct transfer of stretched product to a package.

After considerable consultation with processors and commercial trialling of a number of preferred options, a final prototype packaging system was designed, developed and incorporated into the current meat stretcher version. The design of the commercial packaging system is shown in Figure 1. This system still incorporates components from the earlier concepts based on using a ram that descends into the Boa from above. The ram was used to attach the packaging frame, but we do not believe this is the optimum design for commercial operations.

Therefore, the current proposal is to anchor the package holder to the top surface of the Boa. The holder is little more than a collar which holds the opening of the packaging tube. The collar is mounted so as to hinge from the horizontal position –the position to accept the product from the Boa - to a vertical position, which allows the packaging to be mounted onto the collar.

Operationally, the collar is hinged out of the way to allow the meat to be inserted into the Boa, then hinged down to accept the stretched meat from the Boa. Once the meat is removed, the collar is hinged back to allow another length of packaging to be mounted, and the process is repeated.

A number of different size collars, with associated tubular packaging systems, will constitute the final commercial configuration for packaging the meat following stretching.

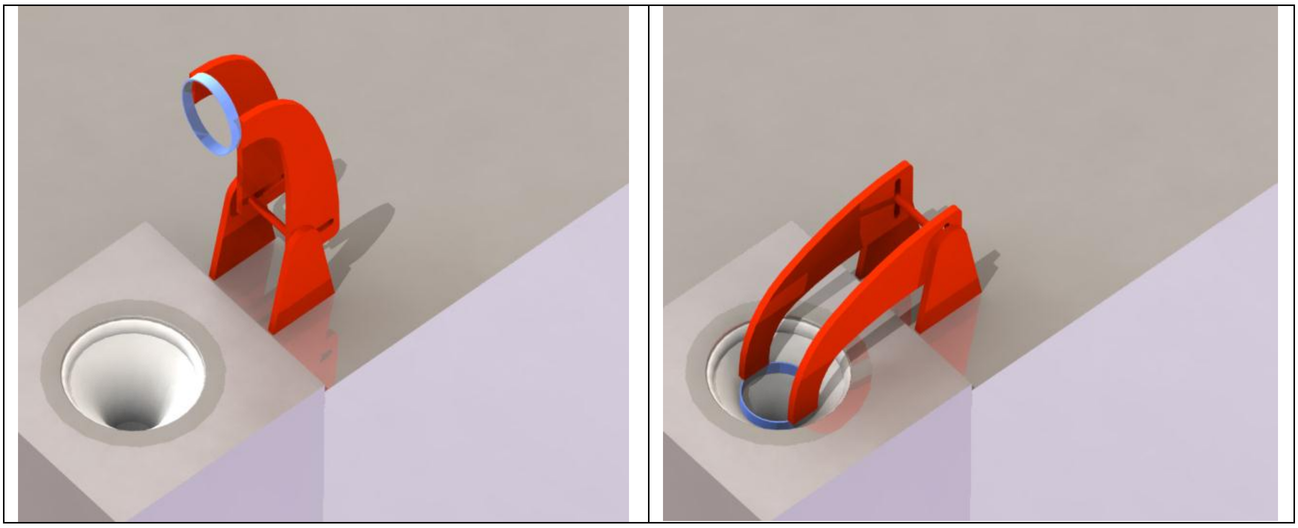


Figure 1: Drawings of the proposed package holder in the up and then inserted position.

Information has been provided by the technical advises and incorporated into the application for US provisional patent. The current draft application is included in this report.

Contents

1 Background

Controlling quality attributes depends substantially on manipulation of the temperature and pH decline after slaughter. Since different muscles in a carcass will have different end uses, processing to optimise the quality of each muscle means that, ideally, each muscle should be subjected to a temperature/pH history that is tailored to its end use. This goal is difficult to achieve in the processing of whole carcasses, since the control of temperature is limited by the size of the carcass and poor heat transfer characteristics of meat: this results in steep temperature gradients within most of the large cuts of, for example, a beef carcass. Manipulating pH decline using electrical stimulation cannot, with present technologies, produce an accelerated pH decline independently in specified muscles, although regions of carcasses could be stimulated independently (eg. legs vs loin).

In addition, hot boned muscles, because they are in a pre rigor state, can be physically stretched to alter sarcomere length and tenderness in a manner analogous to the on-carcass Tenderstretch system of pelvic suspension. However, manipulating hot boned meat also offers some unique advantages. A principle benefit is portion control, which allows otherwise irregular muscle shapes to be manipulated to produce a regular (usually cylindrical) shape. When combined with optimal temperature/pH conditions, improved colour and eating quality benefits will be apparent.

The outcome of the current year's work will be to prove a commercial prototype works for specified hot boned beef cuts/products, and that acceptable product formats can be produced with such technologies. Specifically, the research will address issues with transferring the shaped piece of meat into the casing and be sufficiently flexible for the typical range of meat piece sizes to make the meat stretcher commercially viable. This will be achieved in close consultation with processors and final designs will be commercially validated. Feedback from the industry demonstrations will be considered and incorporated in the development of any industry bulletins. Finally, additional information related to any developments in the meat stretcher will be collated to incorporate into the provisional US patent application.

2 Project Objectives

The objectives of the research are :

- Provide information required for the US provisional patent.
- Report on the performance of the meat stretcher running at full capacity in a commercial environment.
- Report on a commercial packaging system to integrate with the meat stretcher. Incorporate the packaging system into the meat stretcher and run in a commercial plant.
- Conduct benchmark study of selected cuts from fore- and hind-quarter and middles.
- Conduct industry demonstrations of the new commercial unit. Provide additional material in the form of industry bulletins and sample meat products.

3 Materials & Methods

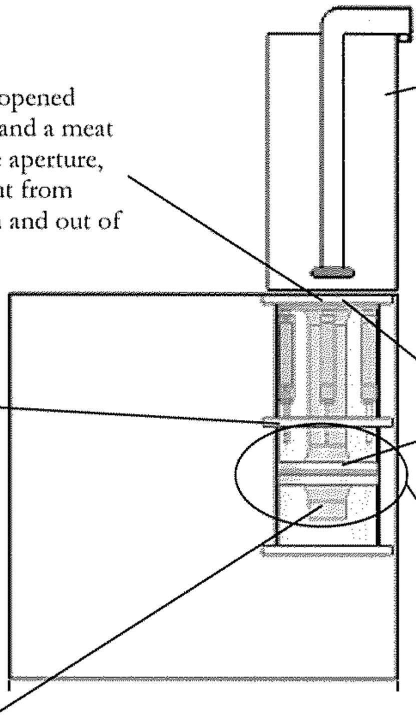
3.1 Provide information required for the US provisional patent.

Information to expand on the previous Australasian Patent was required for the US provisional patent. The following question sheet (see Diagram 1) was used to provide required information:

QUESTIONS FOR PROVISIONAL SPECIFICATION
Meat and Wool New Zealand
Meat Stretching Device and Method
Your ref The Boa Our ref 553591 RDD/kfg

5. When the sleeve is opened under partial vacuum, and a meat cut is dropped into the aperture, what stops the meat cut from falling straight through and out of the sleeve?

6. Why is it necessary for the guard to cover 'the pinch area'? Is it a safety feature, or a feature essential for the working of the device?



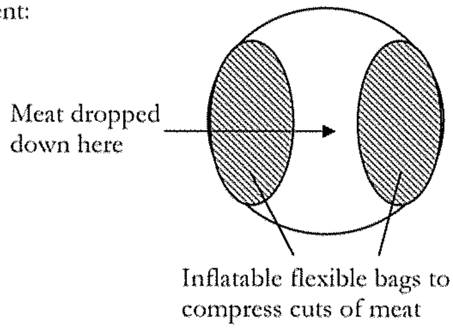
2. Are the stretching cylinders connected to this plate? Is the plate connected to the sleeve? If not, how do the cylinders help stretching?

1. How is the sleeve attached here? Clamped using bolts?

3. Is this just a nozzle? Does it form part of the sleeve? Please elaborate on its function.

4. Can you please elaborate on the various components here in terms of:
- what they are & how they are assembled
- what they do, and
- how it assists with stretching the meat?

7. Instead of a sleeve, could you get satisfactory stretching if you had one or more flexible bags that would inflate and expand to compress the meat cut between them? E.g. the below plan view of an example arrangement:



8. Can The Boa work when the meat cut is not a hot-boned meat cut?

Diagram 1 – Question sheet for provisional specification (US patent).

3.2 Report on the performance of the meat stretcher running at full capacity in a commercial environment.

In previous research (P.PIP.227), the Don/Anzac was demonstrated to ten representatives from two of the major hot boning companies in New Zealand. In the absence of having a prototype to demonstrate in Australia, concepts were discussed with selected Australian beef and lamb processors. While the unit successfully demonstrated the stretching of eye rounds and large cuts from the flap, it was generally felt that the footprint of this unit was too large to be easily accommodated in the majority of hot-boning rooms. Furthermore, to make full use of any commercial unit, it would be necessary for one pipe or tube to accommodate a variety of cuts rather than have tubes that are dedicated to one cut size. Past experience has shown that this would not be possible without compromising the level of stretch and damaging some of the cuts. Therefore, in summary, it was felt that while the overall concept behind this unit was reasonable, some significant modifications should be incorporated into the design and build of a commercial prototype.

The design of the commercial prototype or Boa, is based on air being forced into an outer sleeve of stretching cylinders with the meat cut encased in a flexible food-grade based silicon. As air is forced in, the inner sleeve decreases in diameter and increases in length, thereby stretching the meat within. Once the dimensions of the meat have reached the desired level, the active sleeve is squeezed together at one end, expelling the meat cut upwards into a metal tube. The meat is then expelled from the tube into the appropriate size tube of packaging.

The Boa is a compact unit that can be easily sited in most boning rooms. It is totally encased in a stainless steel cabinet and can be readily cleaned as part of the standard clean-down procedure.

The operational steps are:

> 1) *Inserting the meat to be stretched and formed*. For this operation, a partial vacuum is applied between the cylinder and the sleeve. This causes the sleeve to expand outward towards the sides of the cylinder, so increasing the aperture of the sleeve. This allows the meat cut to be dropped into the sleeve.
>
> 2) *Stretching and forming.* For this step, a positive pressure is applied between the cylinder and the flexible sleeve. This has the effect of compressing the meat and forcing it to elongate along the axis of the cylinder. Because the silicon material of the sleeve is flexible, the sleeve stretches with the meat: this avoids the build up of stresses in the meat caused by friction between the meat and the cylinder wall thereby reducing the risk of damage to the meat.
>
> 3) *Ejecting the meat*. A hollow metallic sleeve is pushed into the unit from above, and this is used to slide the meet into the sleeve. Manual tests of this concept were successful and this approach offers clear benefits: different cut sizes can easily be accommodated by changing the diameter of the metallic sleeve; and, once the sleeve is retracted, it can be used to transfer the stretched meat to the packaging system. .

The meat stretcher, known as The Boa' was installed at Greenlea Premier Meats Hamilton plant in May 2007 and was trialled during the cow kill processing period. Unfortunately, at this stage of the season, the cows that were being slaughtered were small (dressed side weight typically less than 100 kgs) and this restricted the number of cuts that we could put through the stretching unit: The intention of this trial was to focus primarily on striploins, cube rolls and eye rounds, and the unit had been set to handle standard weights and dimensions for these cuts. Therefore, with these smaller cuts, while the shape was successfully reformed into a cylinder, there was very limited, if any stretching. In an effort to overcome some of these issues, cuts from larger animals were selected where possible and on these occasions, cuts from both left and right sides were collected with one cut being put though the Boa and the other packaged normally as a control sample.

Despite these issues, the total time required to trim, stretch, package and manually clip the ends of the bag was on average less than 30 seconds per cut. This means effectively that one Boa unit could keep up with one cut station on a hot boning line and could possibly accommodate 2 cut stations once the packaging component has become more automated.

Samples of each of the 3 cuts were selected at random and returned to Carne Technologies laboratory for meat quality assessment after overnight holding at 15°C.

3.3 Report on a commercial packaging system to integrate with the meat stretcher. Incorporate the packaging system into the meat stretcher and run in a commercial plant.

Effective procedures for packaging meat stretched in the Boa have undergone an evolution in concept with design and operational changes to the Boa itself. Critical to defining a commercial packaging system is identifying the best procedure for removing the stretched meat from the Boa before then transferring the product to the packaging system. The requirement is that this transfer from the Boa to the packaging be simple, reliable, require minimum time and be flexible enough to allow a range of product diameters to be accommodated.

The procedure for extracting the stretched meat from the Boa has undergone a number of changes. The first approach was based on a ‘flow through’ design, where the meat was introduced into the Boa from above, stretched in the elastic sleeve and removed into the packaging from below the sleeve. The main difficulty with this design was accommodating different product lengths.

The process was then modified so that the meat was introduced and removed from above the Boa. After stretching the product and reducing its diameter, a metal tube was inserted into the Boa to fully envelop the stretched product and extract it after it was confined in the stretched state, within the tube. The product could then be pressed out of the tube directly into a packaging system. Different product diameters could be accommodated by using different diameter tubes.

This approach worked effectively and may remain a viable option for the Boa operation under some circumstances. However, it had two limitations: first, multiple steps were required, which slowed the process down and added to its complexity. Second, there was some concern that the introduction of a metal tube into the elastic sleeve of the Boa may contribute to sleeve damage and reduce its lifespan.

During trials with this system, it became evident that it was not always necessary to lower the metal tube fully into the Boa in order to recover the product. If the product did not fully extend to the bottom of the elastic sleeve, the external gas pressure used to compress and stretch the meat also collapsed the sleeve compartment below the meat and this generated an upward force that could expel the meat from the Boa. This peristaltic type action was able, under the right circumstances, to fully transfer the stretched product into the collection tube with only minimal insertion of the tube into the Boa.

3.4 Conduct and report on benchmark study of selected cuts from fore- and hind-quarter and middles.

Unreliability of Boa equipment in producing quantifiable stretching differences made it difficult to undertake comprehensive trials on selected cuts from fore- and hind quarters and middles. A modified laboratory technique for stretching selected cuts was developed at Carne Technologies meat processing facilities. Meat was stretched to the quantifiable levels using a hand wrapping technique that enabled the level of stretching achieved for all the muscles ranged from 43-97%.

and meat quality traits measured. Investigating the meat quality attributes of Bos Indicus and Bos Taurus after pre-rigor manipulation was post-poned in the current benchmark study due accessibility of equipment in Australia.

3.5 Conduct industry demonstrations of the new commercial unit. Provide additional material in the form of industry bulletins and sample meat products.

The Boa was installed into a hot-boning plant (Greenlea, Hamilton). It was not integrated with the packaging line to avoid any risks of hold-ups. However, a range of cuts were brought to the Boa and the performance of the equipment evaluated in consultation with the plant personnel. The equipment was shown to work well and could operate at line speeds if the range of cuts were limited to 3-4.

In a more recent commercial trial in a second NZ plant, the unit operated on the night kill and processing primarily bull ribeyes through the unit. Unfortunately, all the bulls were lower weight specification, which made it difficult to use the standard 100mm diameter bags (which had been previously tested to be suitable for normal weight ranged bull product). The aim was to try and process the ribeyes through the unit with minimal to ideally no trimming apart from cutting the muscle in half. The measurements of normal sized cuts had been previously commercially proven to be processed through the 100mm diameter tubes, achieving at least 20% stretch. In reality, because the bulls were so small, to achieve any level of stretch required us to trim and use our 75mm bags. Due to trimming requirements to fit the 75mm bags, high volumes through the unit was not able to be achieved. Our target of at least 80-100 ribeyes was not achieved. However, the plant was accommodating, and despite the high level of wastage, we managed to generate a few cartons worth of stretched ribeye portions. Majority of stretched product was collected and transferred to laboratories for meat quality assessments and testing. The remainder of the stretched product was retained at the plant for further evaluation and portion control testing.

4 Results

4.1 Provide information required for the US provisional patent.

Refer to Appendix 2 for draft Provisional Patent (US patent).

4.2 Report on the performance of the meat stretcher running at full capacity in a commercial environment.

Despite the small size of all the cuts, the photographs below show that some level of reforming was achieved for all 3 cut types.

A	B

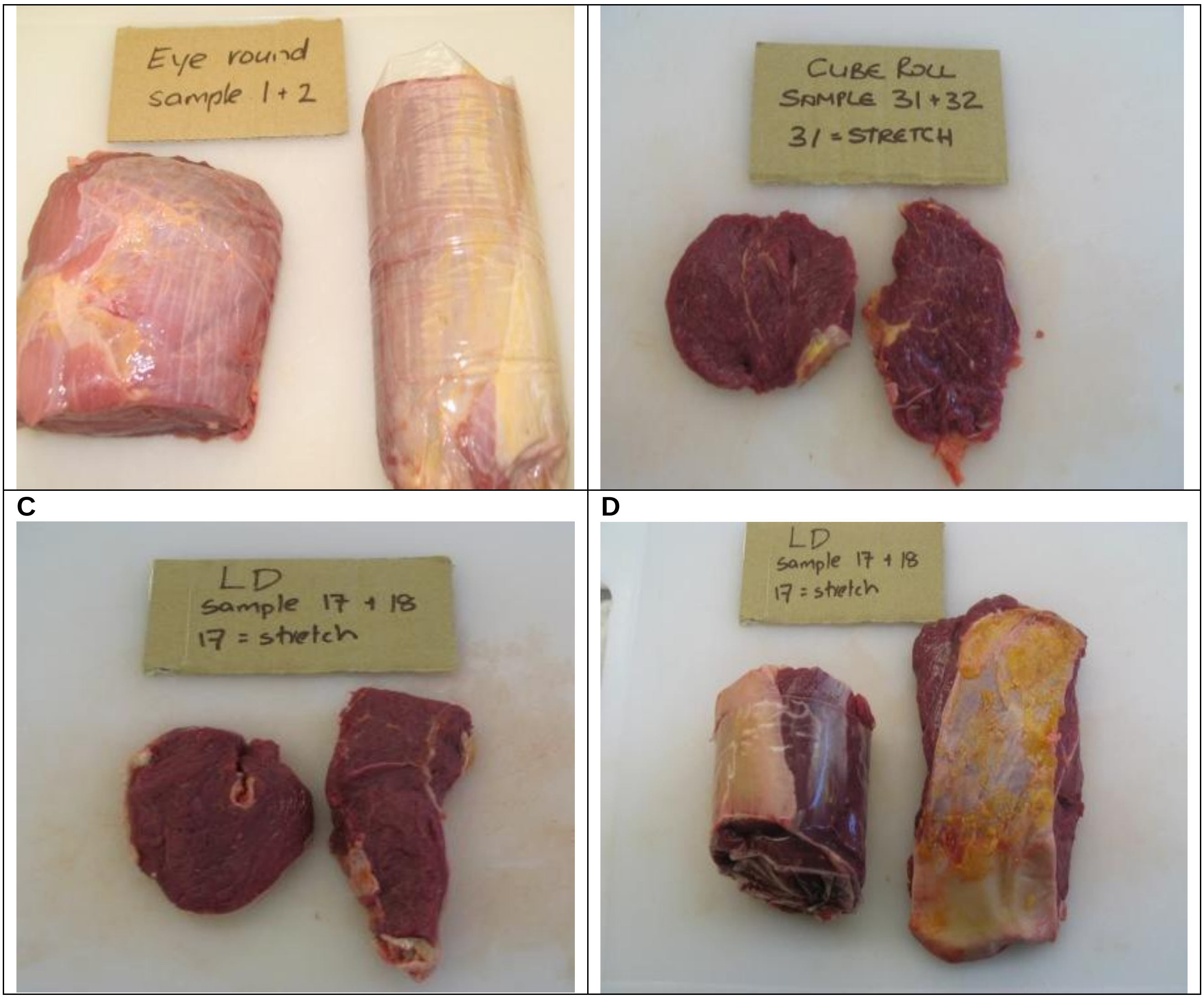


Figure 2 – Degree of stretch over a range of beef cuts including eye round (A), cube roll (B) and striploin (C&D).

The shear force results for both the cube rolls and the striploins were generally low irrespective of treatment (average, across both control and treated was 6.1 and 6.4 respectively). These results are not unexpected as past data from the cow kill at this plant have yielded similar results. However, not withstanding this, the shear force values from the Boa treated samples were consistently lower than the untreated samples, by 1.1 and 1 0 kgf for the cube rolls and striploins respectively. In contrast, the shear force of the eye rounds averaged 14.2 kgf, although the trend continued with the samples that had been through the Boa being at least 1.3 kgf lower than the control counterparts.

The amount of cook loss, the drip loss during retail display and the colour stability did not differ between the control or the Boa treated samples for any cuts.

The next step is to run the Boa at the Riverlands Eltham hot boning plant. The Boa will run for a day in the plant with the primary focus being the stretching and reforming of hot boned cube rolls from bulls. The overall shape of the reformed cuts will be assessed and samples for meat quality will be returned to Carne Technologies for evaluation.

4.3 Report on a commercial packaging system to integrate with the meat stretcher. Incorporate the packaging system into the meat stretcher and run in a commercial plant.

Exploiting the peristaltic effect seemed to offer a significant advantage to packaging the stretched meat. Because it is no longer necessary to insert a collection system into the Boa to recover the meat, it becomes possible to transfer the stretched meat directly from the Boa into the packaging system, given an appropriate mechanism to hold the packaging in place. This approach simplifies and speeds the process of packaging the stretched meat.

To accomplish this, a frame was constructed to hold the packaging at the mouth of the Boa. The first design for this was trialled during the M&WNZ / MLA visit in April but proved to be insufficiently robust. The design of the frame was improved and made more robust and this new system was trialled. While these trials were largely successful, it became clear that two aspects of the process require further consideration: The photograph below shows the Boa with the packaging sleeve attached above (see Figure 3).

Figure 3 – Meat stretcher prototype with a frame constructed to hold the packaging at the mouth of the Boa (ie stretching component).

The following are the critical components and justification for proposed modifications relating to the packaging function :

1. The initiation of the peristalsis/ejection process needs to be controlled. In the initial configuration, the peristalsis began as soon as the sleeve below the product collapsed under the applied gas pressure. In circumstances where the pressure required to collapse the sleeve was

also sufficient to reduce the diameter of the product to fit within the packaging, the process worked very effectively.

However, for larger samples that needed high pressures to ensure the necessary reduction in diameter, the peristalsis began to eject the product before the necessary squeeze had occurred and the product would not enter successfully into the packaging. Hence, a mechanism to initiate the peristalsis only when the appropriate product diameter (and therefore stretch) had been achieved was required. The photograph below shows the packaging sleeve within the lip of the Boa and meat being expelled by the peristaltic action (see Figure 4).

Figure 4 – Meat stretcher prototype with the packaging sleeve within the lip of the Boa enabling meat pieces to be expelled by peristaltic action.

2. The peristaltic action becomes weakest when most of the product has been ejected into the packaging and only the tail end of product remains at the interface of the Boa and the packaging. In most cases, the residual product could be pulled through manually to complete the packaging, but a backup mechanism is needed to ensure that product does not get jammed at this point.

As a solution to these issues, an additional pneumatic ram has been inserted from below the boa, which extends into the product compartment of the sleeve (see Figure 5). When product is stretched, the ram is passively pushed downward by the product but remains in contact with it: as a result, the necessary void in the product compartment below the product cannot form and the peristalsis cannot begin. To initiate peristalsis, the ram is simply pulled downward to produce the required void below the product, the sleeve collapses and the product is pushed upward into the packaging.

Figure 5 – Meat stretcher prototype with additional pneumatic ram has been inserted from below the Boa, which extends into the product compartment of the sleeve.

The ram can also act as a back up for product that fails to transfer fully into the packaging by extending it upwards to push the product into the package. Our expectation at this stage is that the design of the package holder and fine tuning of the Boa operation will reduce this use of the ram to a very occasional incidence. This latest modification will now be trialled extensively during commercial trialling periods.

Note the final design consideration of the commercial packaging system for direct transfer of stretched product to a package is shown in Appendix 1 (Figure 1A). This system still incorporates components from the earlier concepts based on using a ram that descends into the Boa from above. The ram was used to attach the packaging frame, but we do not believe this is the optimum design for commercial operations.

4.4 Conduct and report on benchmark study of selected cuts from fore- and hind-quarter and middles.

i) Effect of stretching on the physical appearance of steaks.

The level of stretching achieved for all the muscles ranged from 43-97%. The level of stretch in the 3 muscles were in the order ST (97.1) > SM (77.9) > BF (43.7), suggesting that higher level of stretch was achieved with muscles having fibres aligned parallel to the length of the muscle (ST and SM) than muscles with mix fibres (BF). Stretching reduced the size of the steaks and improved uniformity, presentation and portion control.

When muscles were stretched using the right tube size, there were no observed physical defects. Some of the physical defects observed include muscle fibre bundle damage, breakage of fibres in muscles with fibres running parallel to the direction of stretch (ST & SM), gaping and failure to maintain shape uniformity particularly in fatty areas in muscles with fibres running in different directions along the stretch (BF). This physical damage is caused due to failure to match muscles to the right stretching tubes resulting in overstretching and other physical defects.

ii) Effect of stretching on meat quality attributes.

Stretching the muscles pre-rigor improved the tenderness and reduced the drip loss significantly at all storage periods (Table 1). Stretching did not affect the colour of the meat but increased the amount of moisture loss during cooking (Table 1). The reason for the higher cook loss in stretched muscles is because raw stretched muscles had higher free moisture due to less drip and on cooking more of this moisture is lost in the stretched muscles compared to control. The opposing effect of stretching on drip and cook loses suggest physical rather than biochemical factors were responsible for the difference between control and stretched muscle. Higher cook loss is less likely to affect merchandising of stretched steaks.

The most important attributes that determine acceptability at the point of sale such as colour or visible drip have either been improved or not affected by stretching, and tenderness – being the most important attribute that affects acceptability of cooked meat – has been improved by stretching.

Quality Attribute	Rigor		24 hrs		48hrs		72 hrs		120		*P* level
	C	S	C	S	C	S	C	S	C	S	
pH	5.46	5.50	5.50	5.48	5.49	5.48	5.47	5.45	5.37	5.33	0.06
Drip loss, %	ND	ND	2.2	1.6	3.1	1.7	3.9	2.4	6.6	3.1	0.001
Tenderness, KgF	10.3	9.2	8.1	7.7	8.1	7.0	7.9	7.0	7.3	6.8	0.001
Cook loss, %	ND	ND	28.2	32.6	24.7	30.5	26.4	28.3	33.4	37.6	0.001
Colour, a*	18.7	18.5	18.6	17.8	17.9	16.9	15.6	14.9	14.5	14.0	ND
P level = Statistical significance of storage time on the attribute; C = Control; S = Stretched; ND = Not determined											

Table 1- Effect pre-rigor muscle stretching on changes in meat quality attributes with storage time.

4.5 Conduct industry demonstrations of the new commercial unit. Provide additional material in the form of industry bulletins and sample meat products.

Generally speaking, most of the feedback we have had from NZ processors is that they would like to use the stretching technology to generate a portion controlled product that could be frozen within 2 or 3 days of slaughter. Once frozen, they would then slice the rolls into portion controlled steaks and sell in a free-flow pack. The tenderness advantages would therefore be critical to this process.

From these previous commercial trials and discussions, the following NZ market developments are proposed :

- The high level of labour currently used in NZ hot- and warm-boned plants for hand wrapping product or bon-bon wrapping may be dramatically reduced using semi- or fully automated processes such as Boa. Specifically, there is a high level of manual wrapping of ribeyes and fillets (primarily) in response to specific market needs around a more cylindrical shaped product. Processors have been able to successfully produce this product in the past, and some even go a stage further, and after ageing and freezing, carry out further reforming before re-freezing. This is all in an attempt to get a portion controlled product. Having listened to processors, it is easy to see why the Boa offers so many advantages for them.
- Through preliminary discussions at this point, multiple NZ plants have indicated interest to produce stretched and reformed product and evaluate immediately with their customer base. This demonstrates some level of potential market uptake.
- Portion control of NZ cold-boned product is taking place in overseas markets e.g. Taiwan - again at significant cost. Therefore, existing markets are already known for this product. The Boa allows our processors to undertake the value-adding here prior to export and allows significant cost capture.
- The Boa offers advantages over existing bazooka or meat-filler technologies.
- The feedback has been that processors wish to be involved in development and further commercialisation of the technology. NZ processors involved in early demonstrations have

indicted that they would be happy to provide us with any market feedback that they acquire but would be uncomfortable with identifying who the markets were.

Concepts of the meat stretcher were canvassed with several Australian processors in general discussions. All participants indicated any interest in further plant demonstrations and opportunities to have a play and produce commercial samples for clients to provide feedback on.

Specifically, one major Australian lamb processor was invited to participate in a workshop where several products concepts were discussed. Again preliminary feedback provided by the meat processor's marketing and international marketing teams was positive. Specifically a number of value-added product opportunities were identified for current chilled and warm-boned processes. It was noted that the meat stretcher might be used for chilled carcase to add value to boneless lamb and/or mutton forequarter and backstraps from shaping and portion controlling. This was identified as immediate opportunity. A further opportunity for warm- and hot- boned product was identified, in lieu of its functional benefits and producing value added products requiring binding without the use of salt was seen as a major benefit. Also shaping and portioning was a value added priority. Ongoing discussions were underway to further evaluate market opportunities.

Similarly for Australia, a preliminary market sector analyses has identified the following opportunities :

- Wet dish market - while a cheap wet dish market still desires certain characteristics in meat products. Expect that a shape consistent with the size of the template of there portioning equipment would be desirable and welcomed by this market.
- Airline catering and function work needs to be considered.
- Expect that shape and plate profiles are still very important. Expect markets to be very excited at the prospect of the Boa shaped primals, they would just be choosing lower grade carcass primals than the middle to high food service markets as is to be expected and the whole rationale behind meat grading and the AUS Meat language.
- Portioned controlled roasts for retail would potentially be a significant market for BOA. If customers could be provided with exact cooking times for consistent roasts the whole category skew would lift, not to mention the fact that the added benefit would also be more tender meat.
- Boa may be used to pack all product categories to suit the different markets based on historical purchase patterns, remembering that the packing technique will have no effect on Aus meat language or AUS Meat ciphers regarding the age and feed. The market will continue to purchase the same product but would choose to look for Boa extruded products based on the innovation of shape according to the market.

It is proposed that in future once a second unit can be built and shipped to Australia, that the equipment might be located a central location for processors to be demonstrated the equipment. Any interest might be followed up with the processor having access to the equipment over a week's production period for example, and producing commercial samples to demonstrate to customers.

5 Conclusion

Development of the meat stretcher's packaging system is proposed in the current research. The proposal is to anchor the package holder to the top surface of the Boa. The holder is little more than a collar which holds the opening of the packaging tube. The collar is mounted so as to hinge from the horizontal position – the position to accept the product from the Boa - to a vertical position, which allows the packaging to be mounted onto the collar.

Operationally, the collar is hinged out of the way to allow the meat to be inserted into the Boa, then hinged down to accept the stretched meat from the Boa. Once the meat is removed, the collar is hinged back to allow another length of packaging to be mounted, and the process is repeated.

A number of different size collars, with associated tubular packaging systems, will constitute the final commercial configuration for packaging the meat following stretching.

All steps in the development process received commercial approval.

The following conclusions were reached within the parameters of the commercial trialling :

- The device developed in this study is capable of stretching muscles of different sizes by up to 97% of their original length
- Muscles stretched using the right diameter stretching tube had less physical defects than those stretched with inappropriate size tubes.
- Muscles with fibres aligned parallel to the direction of stretch tend to stretch better and had less physical defects as a result
- Meat from stretched muscles had less drip and were more tender than from corresponding non stretched control muscles
- The improvement in tenderness and the reduction in drip loss due to stretching occurred as early as at rigor for tenderness and 24 hrs after rigor for drip loss.
- Stretching pre-rigor muscles had no effect on the bloomed colour of the resulting meat.
- Meat from stretched muscles had higher cook loss than from non-stretched.

6 Recommendations

This new approach to removing the stretched meat requires only modification of the existing stretcher design and ongoing evaluation to quantify the quality enhancement to hot-boned meat over a range of cuts and commercial conditions. Furthermore, the following R&D is proposed in the next phase:

- Ongoing modifications to the Boa prototype required primarily mainly in packaging.
- Aim is now to feed directly into the packaging sleeve.
- Also modifications to the pneumatics surrounding the white lady.
- Manufacture of the new mould is well underway, and this will allow us to use the stronger material to produce longer lasting white ladies. (ie 650 as opposed to 330 relaxed measurements).

It is proposed that in future once a second unit can be built and shipped to Australia. Demonstrations may be delivered initially at a central location. Any interest might be followed up with the processor having access to the equipment over a week’s production period for example, and producing commercial samples to demonstrate to customers.

Appendix 1 – Meat stretcher specifications drawing

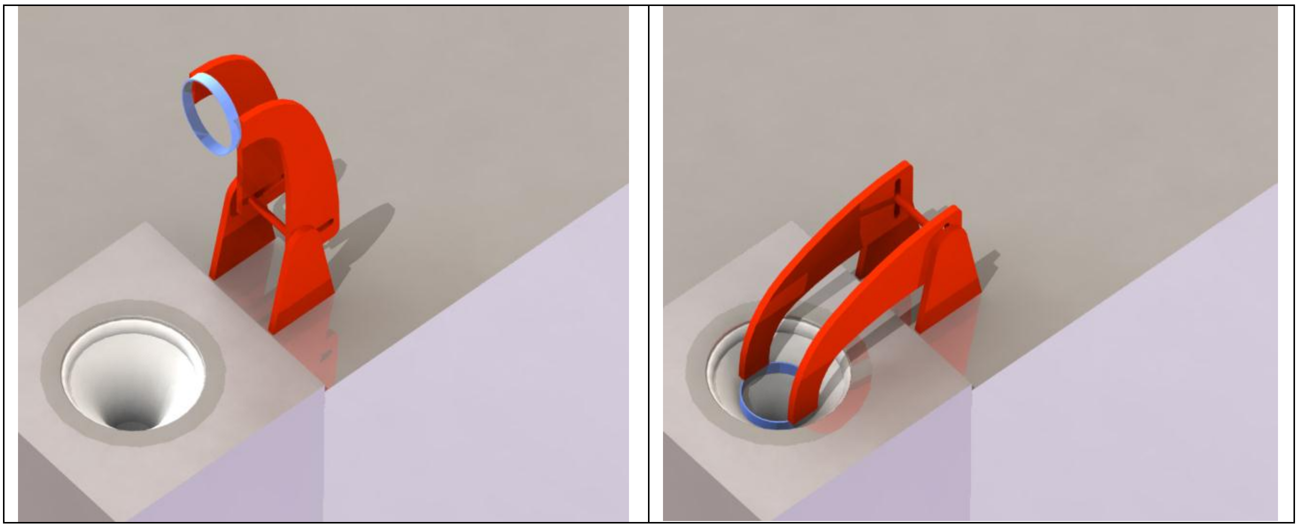


Figure A1: Drawings of the proposed package holder in the up and then inserted position.

Appendix 2 – Draft Patent Application

MEAT STRETCHING DEVICE AND METHOD

FIELD OF THE INVENTION

The present invention relates to a meat stretching device and method. In particular, but not exclusively, the present invention relates to a meat stretching device and method using a flexible sleeve.

BACKGROUND TO THE INVENTION

The processing of a carcass and the meat extracted from the carcass has a significant influence on the quality attributes of the meat. This is because various changes take place in the biochemical and structural attributes of muscle tissue in the meat during processing. This is especially so when the meat transforms from a pre-rigor-mortis state to a post-rigor-mortis state.

There are two main factors that determine the pre-rigor state of the meat – the rate of pH fall and the rate of cooling of the meat. The rate of pH fall can be improved by subjecting the meat to electrical stimulation, while the rate of cooling of the meat can be improved by reducing the size of the cut of meat. Any reduction in cut size is preferably done before the carcass is chilled and while the muscles are still in a pre-rigor state. This process is generally referred to as hot boning.

Once meat is cut to size, its shape may be manipulated. Manipulation of meat shape has been shown to improve the meat's tenderness and colour stability, and reduce its drip loss. Also, the manipulation of the shape of the meat allows the portion size of the meat to be controlled.

An example way in which the shape of a meat cut can be manipulated is disclosed in US Patent 6,824,846. In particular, the patent discloses a method of packaging objects, such as meat, where the object to be packaged is pushed through a funnel and into an elastic packaging sleeve. Given its elastic nature, the packaging sleeve wraps closely around the object. Where meat is packaged, the process of pushing the meat through the funnel manipulates its shape, which is then maintained by the elastic packaging sleeve.

In this specification, where reference has been made to patent specifications, other external documents, or other sources of information, it is generally for the purpose of providing a context for discussing the features of the present invention. Unless specifically stated otherwise, reference to such external documents or sources of information is not to be construed as an admission that such documents or sources of information in any jurisdiction are prior art, or form part of the common general knowledge in the art.

It is an object of the present invention to either provide an improved device and method to stretch meat or at least provide the public with a useful choice.

SUMMARY OF THE INVENTION

In one form, the present invention relates to a meat stretching device comprising:

- a receptacle; and
- a flexible sleeve mounted within the receptacle, the flexible sleeve having a cross-section that defines an aperture to receive one or more cuts of meat;
- wherein the receptacle is connectable to an air pressure device that is capable of generating a positive pressure in the receptacle to cause the flexible sleeve to constrict around and stretch the one or more cuts of meat that are received in the aperture.

Preferably, the air pressure device is further capable of generating at least a partial vacuum in the receptacle to cause the aperture of the flexible sleeve to widen to receive one or more cuts of meat.

Preferably, the device further comprises a pushing rod to push the one or more cuts of meat out of the constricted flexible sleeve.

Preferably, the device further comprises one or more stretching cylinders connected at one end to the receptacle, and connected at another end to the flexible sleeve to assist with the stretching of the one or more cuts of meat.

Preferably, the flexible sleeve is a silicon sleeve.

In another form, the present invention relates to a meat stretching device comprising:

- a receptacle; and
- a flexible sleeve having a first end and a second end, and a cross-section that defines an aperture, the first end being adapted to receive one or more cuts of meat and the second end being adapted to allow the one or more cuts of meat to be removed from the flexible sleeve;
- wherein the flexible sleeve is mounted within the receptacle such that an airtight volume is formed between the flexible sleeve and the receptacle, and wherein the flexible sleeve constricts around and stretches the one or more cuts of meat when the airtight volume is subjected to positive pressure.

Preferably, the device further comprises a packaging arrangement arranged adjacent the second end of the flexible sleeve.

In another form, the present invention comprises a method of stretching meat using a flexible sleeve, the method comprising the steps of:

- inserting one or more cuts of meat into an aperture defined by a cross-section of the flexible sleeve;
- generating a positive pressure in an airtight volume between the flexible sleeve and a receptacle containing the flexible sleeve to cause the flexible sleeve to constrict around and stretch the one or more cuts of meat.

Preferably, the method further comprises the step of generating at least a partial vacuum in the airtight volume to widen the aperture before inserting the one or more cuts of meat into the aperture.

Preferably, the method further comprises the step of pushing the one or more cuts of meat out of the constricted flexible sleeve.

Preferably, the method further comprises the step of stretching the sleeve lengthwise to assist the flexible sleeve constrict around the one or more cuts of meat.

The term ‘comprising’ as used in this specification means ‘consisting at least in part of’, that is to say when interpreting statements in this specification which include that term, the features, prefaced by that term in each statement, all need to be present but other features can also be present. Related terms such as ‘comprise’ and ‘comprised’ are to be interpreted in similar manner.

The present invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features. Where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

BRIEF DESCRIPTION OF THE FIGURES

Preferred forms of the device and method of the present invention will now be described with reference to the accompanying figures in which:

Figures 1a- 1d show a side view cross-sectional schematic of the device of the present invention,

Figure 2a shows a perspective view of the preferred form device of the present invention,

Figure 2b shows a plan view of the device of Figure 2a,

Figure 2c shows a side view of the device of Figure 2a, and

Figure 2d shows a front view of the device of Figure 2a.

1/2

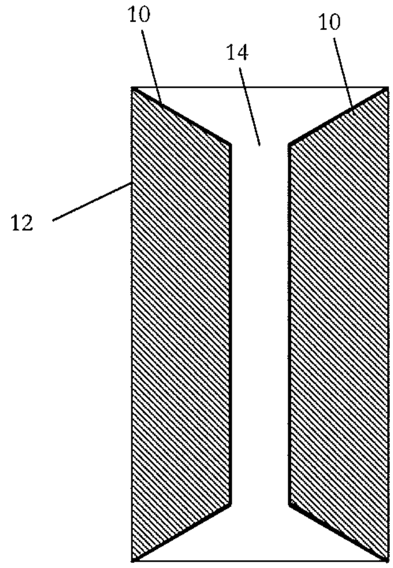


FIGURE 1a

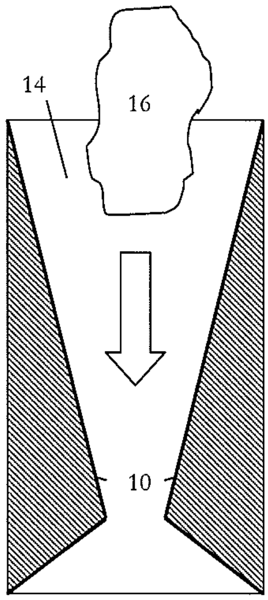


FIGURE 1b

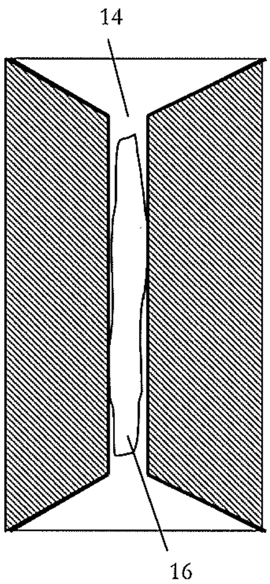


FIGURE 1c

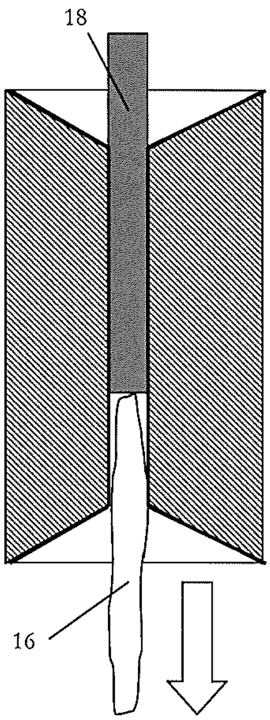


FIGURE 1d

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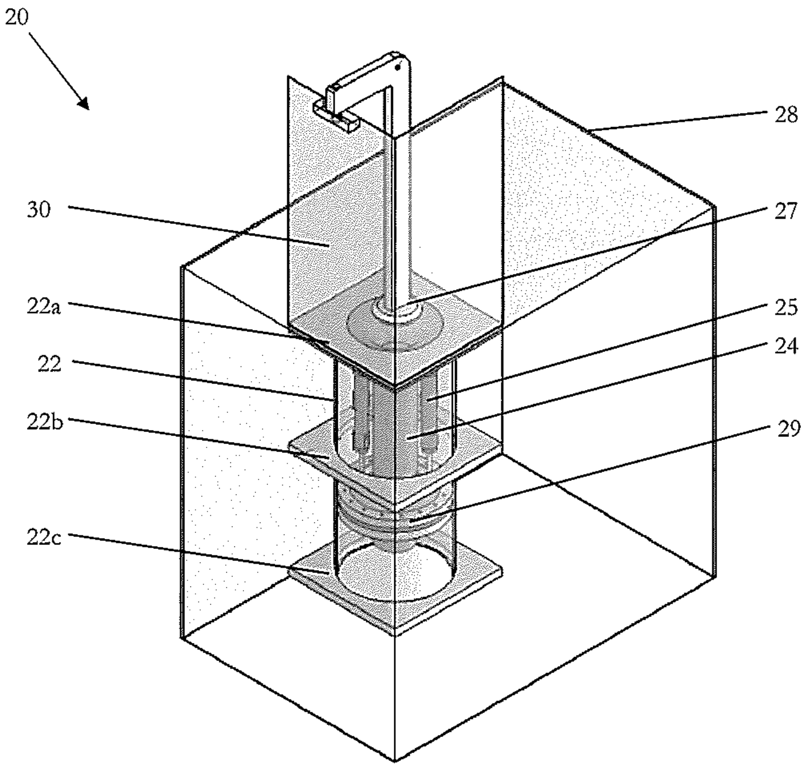


FIGURE 2a

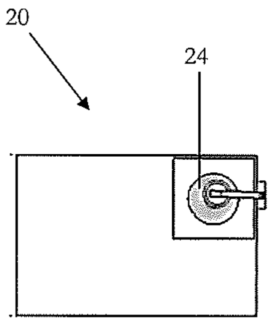


FIGURE 2b

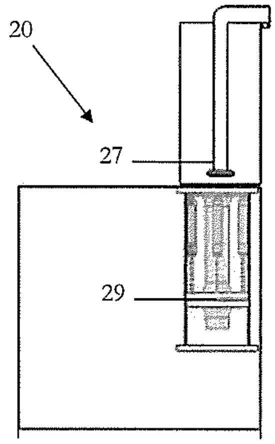


FIGURE 2c

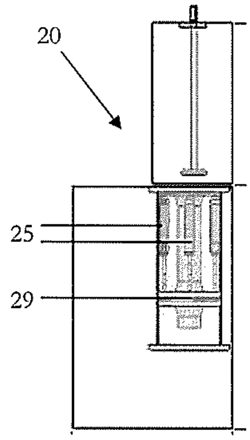


FIGURE 2d

DETAILED DESCRIPTION OF THE PREFERRED FORMS

A cross-sectional schematic of one form of the device of the present invention is shown in Figures 1a-d. In Figure 1a, a flexible sleeve 10 is shown attached to a receptacle 12. In one preferred form, the sleeve 10 is a silicon sleeve. Of course materials other than silicon may be used instead; suitable alternatives to silicon include plastics such as polyethylene terephthalate, polyvinyl chloride and polypropylene.

In the figures, the flexible sleeve 10 is illustrated as having a tapering shape near the ends of the sleeve. This tapering shape is the result of stretching the edges of the preferred form sleeve, which has a diameter smaller than that of the receptacle, to attach to the edges of the receptacle 12. Persons skilled in the art will appreciate that various forms of sleeve can be used, which may or may not result in a similar tapering shape when stretched. All that is required is for the sleeve to be able to constrict around cuts of meat, as will be described in detail below.

When not in use, the area between the sleeve 10 and the receptacle 12 (herein referred to as the interior of the receptacle), which is shown in shade, is under ambient pressure. Also, when not in use, an aperture 14, which is defined by the cross-section of the sleeve 10, preferably has a width smaller than the cuts of meat to be stretched.

The preferred form method will now be described with reference to Figures 1b-d. As illustrated, the interior of the receptacle (shown in shade) is subjected to at least a partial vacuum generated by an air pressure device. This causes the wall of the sleeve 10 to be drawn closer to the wall of the receptacle. This, in turn, causes the aperture 14 defined by the sleeve 10 to widen. In the form shown, only the top portion (called the ‘working area’) of the sleeve 10 is caused to widen, leaving at least part of the bottom of the sleeve 10 to remain small enough to stop the meat cut from falling right through the sleeve.

Skilled persons will appreciate that the step of widening the sleeve is not essential as the initial size of the aperture may be wide enough to receive cuts of meat. In the figure, the cut of meat 16 is shown to be a large cut, which requires the aperture 14 to be widened. Preferably, the initial size of the aperture 14 is small, which would necessitate the widening of the aperture before cuts of meat can be inserted into the aperture. The benefit of a small initial size of the aperture 14 is that the initial expansion of the sleeve under partial vacuum to receive the meat cut will assist with further stretching of the meat cut as the sleeve returns to its natural, smaller size when the partial vacuum is removed.

In Figure 1c, the interior of the receptacle 12 (shown in shade) is subjected to positive pressure generated by the air pressure device. Positive pressure is essentially pressure that is greater than the ambient pressure surrounding the receptacle. In most applications of the present invention, positive pressure will be pressure greater than atmospheric pressure. The positive pressure forces the sleeve 10 to constrict around the meat cut 16. As pressure is applied, the meat cut 16 is squeezed and stretched along the axis of the sleeve 10. This reduces the diameter of the meat cut 16, and increases the length of the meat cut 16 as illustrated. Where a silicon sleeve or similar low-friction sleeve is used, the stretching of the meat cut 16 can be made easier and less damaging to the meat cut 16.

Referring now to Figure 1d, a piston-like pushing rod 18 is preferably used to push the stretched meat cut 16 out of the constricted sleeve 10. Although the figure shows the meat cut 16 being ejected from the bottom of the flexible sleeve, the present invention can be worked such that the meat cut 16 is ejected from the top part of the flexible sleeve. One way to do this will be described later in this specification.

Regardless of whether the stretched meat cut 16 is ejected from the top or bottom of the sleeve, in the preferred embodiment, the device includes a packaging arrangement to receive the stretched meat cut 16. The packaging arrangement may use an inflexible packaging to ensure the meat cut 16 retains its stretched form until rigor mortis sets in.

A preferred form of the meat stretching device of the present invention is shown generally with arrow 20 in Figures 2a-d. The device 20 includes a receptacle 22, which is preferably a cylindrical receptacle having supporting plates 22a, 22b and 22c. The form of the receptacle shown in the figure is merely illustrative; where necessary or desired, the receptacle 22 can be made to be in another shape, size or configuration.

The device 20 also includes a flexible sleeve 24 that is mounted within the receptacle 22. In the form shown, the flexible sleeve 24 is attached to the supporting plate 22a on one end using, for example, bolts, clamps or the like. On the other end, the flexible sleeve 24 is attached to a plate 29. In the preferred form, the plate 29 comprises two or more plates that are attached together and that is movable or slidable along the receptacle 22 using one or more cylinders 25. The plate preferably comprises two or more individual plates that clamp at least part of the flexible sleeve to achieve an acceptable seal in the interior of the receptacle (i.e. between the sleeve and the receptacle walls). The above forms of attaching the sleeve to the receptacle are, of course, not the only forms of attachments that can be used. Skilled people will recognise that the purpose of the attachment is to achieve a substantially air-tight seal for the interior of the receptacle 22. Any attachment that can achieve this can be used in the present invention.

Although not shown in the figure, the receptacle 22 is connectable to an air pressure device. In the preferred form, the air pressure device is arranged to selectively generate at least a partial vacuum or positive pressure within the interior of the receptacle.

As mentioned earlier, one or more cylinders 25 are provided in the preferred form device to controllably move or slide the plate 29 along the receptacle. This is required in the preferred form to control the extent to which the flexible sleeve 24 is able to open and close to stretch cuts of meat. For instance, when vacuum or at least partial vacuum is generated in the interior of the receptacle, atmospheric pressure on the outside of the flexible sleeve 24 has a greater tendency to contract and shorten the sleeve than to expand the aperture defined by the flexible sleeve 24. To stop the sleeve from contracting and shortening, the one of more cylinders 25 are provided to force the sleeve length to remain the same as (or to be greater than) the length prior to the vacuum or partial vacuum being generated. The one or more cylinders also control the sleeve length after the vacuum or partial vacuum is removed to control the extent to which the aperture defined by the sleeve closes.

Preferably, the device includes a pushing rod, such as piston 27, to eject meat that has been stretched by the device. The ejected meat is preferably received in an inflexible packaging sleeve that maintains the shape of the meat until rigor mortis sets in. For this, a packaging arrangement may be provided adjacent the end of the flexible sleeve from which the stretched meat is ejected. Alternatively or additionally, the piston 27 itself is arranged to receive an inflexible packaging sleeve. For instance, the packaging sleeve could be a stainless steel sleeve that is coated with a low-friction coating, such as Teflon. The stainless steel sleeve could be used to temporarily hold the meat in its stretched form before it is packaged in a final packaging sleeve. Where such a packaging sleeve is used, the bottom end of the flexible sleeve is sealed or otherwise closed before the piston 27 is pushed into the flexible sleeve 24. The movement of the piston 27 into the sealed flexible sleeve 24 then causes a pressure build-up in the flexible sleeve, which results in the stretched meat being pushed upwardly toward the piston 27. By arranging a packaging sleeve about the piston 27, the stretched meat is forced to enter the packaging sleeve. Once in the packaging sleeve, the piston 27 can be pulled out of the flexible sleeve while retaining the meat within the packaging sleeve. In this form, the stretched meat is forced to remain in its stretched form even after extraction from the flexible sleeve.

It is also preferable for the device 20 to be provided in an enclosure 28, which may house the control system of the device 20 and the air pressure device (not shown).

In some embodiments, the device also preferably includes a guard 30. The guard 30 covers a pinch area that forms when the sleeve returns to its original shape after the positive pressure is removed. Also, in some embodiments, the device may eject stretched meat from the flexible sleeve 24 by pulling the plate 29 upwardly using the cylinders 25. This results in the flexible sleeve 24 being at least partially pushed out of the receptacle before it is pulled back into the receptacle for further stretching processes. The guard 30, in these embodiments, can help reduce the risk of a user accidentally coming into contact with the flexible sleeve 24 and being injured as the flexible sleeve 24 is pulled back into the receptacle.

The foregoing describes the present invention and its preferred forms. Alterations and modifications that are obvious to those skilled in the art are intended to be incorporated within the scope of the present invention.

CLAIMS

1. A meat stretching device comprising:
   - a receptacle; and
   - a flexible sleeve mounted within the receptacle, the flexible sleeve having a cross-section that defines an aperture to receive one or more cuts of meat;
   - wherein the receptacle is connectable to an air pressure device that is capable of generating a positive pressure in the receptacle to cause the flexible sleeve to constrict around and stretch the one or more cuts of meat that are received in the aperture.

2. The meat stretching device as claimed in claim 1 wherein the air pressure device is further capable of generating at least a partial vacuum in the receptacle to cause the aperture of the flexible sleeve to widen to receive one or more cuts of meat.

3. The meat stretching device as claimed in claim 1 further comprising a pushing rod to push the one or more cuts of meat out of the constricted flexible sleeve.

4. The meat stretching device as claimed in claim 1 further comprising one or more stretching cylinders connected at one end to the receptacle, and connected at another end to the flexible sleeve to assist with the stretching of the one or more cuts of meat.

5. The meat stretching device as claimed in claim 1 wherein the flexible sleeve is a silicon sleeve.

6. A meat stretching device comprising:
   - a receptacle; and
   - a flexible sleeve having a first end and a second end, and a cross-section that defines an aperture, the first end being adapted to receive one or more cuts of meat and the second end being adapted to allow the one or more cuts of meat to be removed from the flexible sleeve;
   - wherein the flexible sleeve is mounted within the receptacle such that an airtight volume is formed between the flexible sleeve and the receptacle, and wherein the flexible sleeve constricts around and stretches the one or more cuts of meat when the airtight volume is subjected to positive pressure.

7. The meat stretching device as claimed in claim 1 further comprising a packaging arrangement arranged adjacent the second end of the flexible sleeve.

8. A method of stretching meat using a flexible sleeve, the method comprising the steps of:
    - inserting one or more cuts of meat into an aperture defined by a cross-section of the flexible sleeve; and
    - generating a positive pressure in an airtight volume between the flexible sleeve and a receptacle containing the flexible sleeve to cause the flexible sleeve to constrict around and stretch the one or more cuts of meat.

9. The method as claimed in claim 8 further comprising the step of generating at least a partial vacuum in the airtight volume to widen the aperture before inserting the one or more cuts of meat into the aperture.

10. The method as claimed in claim 8 further comprising the step of pushing the one or more cuts of meat out of the constricted flexible sleeve.

11. The method as claimed in claim 8 further comprising the step of stretching the sleeve lengthwise to assist the flexible sleeve constrict around the one or more cuts of meat.

Appendix 3 – Industry brochure

STRETCHING PRIMAL MEAT PRIOR TO RIGOR

Prepared by : David Carew, MLA
28 May 2007

Stretching primal's prior to rigor is a well known means of decreasing the amount of contraction by sarcomeres, therefore and improved eating quality is possible. There is a wealth of research supporting this theory however little has been done to develop this technology in Australia due to the limited amount of hot carcass boning plants.

MLA in collaboration with Meat Wool New Zealand are coordinating further research on this and developing prototype equipment to automate the process. While this research continues there has been an increased level of new interest on this process due to another benefit from the stretching and containing method.

This process produces perfectly formed logs of whole muscle meat primal and is of particular interest to the Food Service and Quick Service markets. The potential to service rotisserie roast beef markets with tight weight tolerance single muscle primal's is now closer than ever to becoming a feasible practise that could see elements of this technology spill over into traditional cold boning plants.

Research is being initiated into trialling the removable of the *m. gluteo bicep* muscle, and the m. *tensor fascia latea* from the kill floor and processed using this technology. The potential of a fully portion controlled mini roast products from these undervalued muscle's could revolutionize the hot deli roast meat market segment with the added benefit of carcasses going into chillers 7% lighter around the leg area which will assist the whole chilling process.

A fully automated stretching device is currently under the final stages of construction.

An innovative hand wrapping technique to produce similar samples could well see this process piloted in plants prior to arrival of the new machine which will enable plants to cost effectively access the commercial potential of this new process.

(end)

Appendix 4 – Mechanical Stretching – General Information.

Mechanical stretching of pre-rigor meat for enhanced quality.

Background

It has long been recognised that the quality attributes of meat are influenced by the degree of contracture of the muscle. Stretch or contracture is reflected in the sarcomeres, the structure of muscle responsible for generating force. Sarcomere length (SL) is therefore a measure of the degree of shortening or stretching of a muscle.

Contracture of a muscle to produce a shortened sarcomere toughens meat. At contractures of up to 40%, the initial toughness of meat, defined as the toughness at rigor mortis, is increased in proportion to the shortening but, with ageing, will become acceptable tender. At contractures greater than 40%, meat becomes severely and irreversible tough.

Conversely, when meat is stretched beyond the normal resting length, the initial toughness is reduced. In effect, stretching replaces, to some degree, the need for ageing to allow tenderisation.

In a conventional cold boning meat processing specification, where carcasses are butchered after rigor mortis and chilling, the opportunities offered by stretching of muscles can only be realised by manipulating the hanging posture of the carcass. Pelvic suspension is a longstanding procedure to cause muscles on the carcass to be stretched, but this technique has significant cost associated with it due principally to the greater amount of chiller space required on a per carcass basis.

New Zealand has largely pioneered the commercial development of hot boning carcasses. Traditionally, hot boning was associated with the production of manufacturing beef and the process was developed with a process efficiency focus and little regard to end-point meat quality. As a result of this, hot boning was typically associated with poor and highly variable meat quality and it's use was limited to the production of bull and cow meat. However more recently, hot boning has undergone an evolutionary change with many plants now tailoring their process to generate high quality chilled beef destined for overseas markets. Many of these process optimisation procedures have focussed on the more effective control of pH/temperature profiles and the resulting quality has improved dramatically.

Typical meat quality issues:
Poor shape of hot-boned primals
One area that continues to cause problems in some markets is the fact that some cuts such as rumps do not 'set well' and the D end of the cut face can collapse making it difficult to cut and prepare for retail. This has created problems for some hot-boning plants in their overseas markets.

Tenderness variability
Furthermore, with both hot and cold-boning processing, there is always large variability in tenderness. This variability extends through most of the higher value cuts and can result in as much as 3 to 4 shear force units for the same cuts from different carcasses. With this area of the process optimised, many processors are now considering the unique opportunities offered by manipulating hot boned meat.

Poor Shape
Many cuts have a shape that does not lend itself well to portioning. This inevitably results in a significant amount of wastage when these cuts are trimmed to retail specifications.

Lower value cuts
The majority of forequarter cuts and several of the hind quarter have inferior eating quality. This is unavoidable and is due largely to the higher content of collagen in these cuts and/or the degree of elastin present. However, many of these cuts have some good quality features such as a good flavour, good texture, and many will reach a reasonable tenderness level but if given long ageing periods. There is significant opportunity in stretching these cuts to overcome the issues presented by high connective tissue content and thus upgrade them to a better eating quality.

Therefore in an effort to address these issues/opportunities, the concept of stretching pre-rigor meat was developed.

Procedure for stretching hot boned meat

An inherent property of muscle tissue is that it is isovolumetric: the volume of the muscle remains constant irrespective of sarcomere length. This means that compressing the muscle perpendicular to the direction of the fibres will force the muscle to extend in the direction parallel to the fibres: in effect, the muscle is stretched.

Benefits and opportunities

- A clear benefit is the improvement in tenderness. The extent of this benefit depends on the muscle and the extent of the stretch. Muscles with a parallel fibre direction respond most effectively to stretching.
- Portion control: After stretching, meat adopts an even cylindrical shape that is ideally suited to identical portions. Additional shapes can be considered but have not yet been developed.
- Restructuring: Prerigor meat held together under compression during the pre-rigor period and during subsequent storage will bind together even without the use of binding agents. These have been shown to hold together even after cooking.
- Meat colour: For reasons that have yet to be defined, both meat colour and colour stability is improved after stretching.
- Process optimisation: Processing muscles individually through a tube-based stretching system offers opportunities for additional process control: these include optimised cooling regimes, individual muscle stimulation, integrated quality measurements systems based on, for example, NIR or NMR.

Industry consultation
After one year of experimental work to prove the concept of using pre-rigor stretching to improve meat quality, the NZ hot-boning processors were consulted on the concept and potential benefits offered by this technique. The general response was positive. All could identify immediate benefits to their business – these were as follows (in decreasing level of importance).

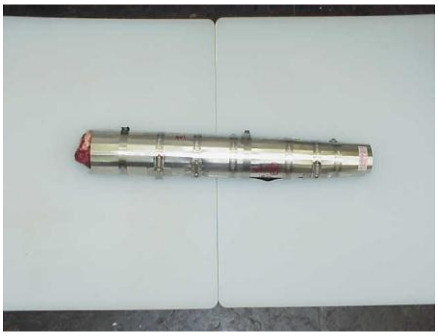
1. Opportunity to produce a portion control product for a range of cuts.
2. Upgrade the value of cuts from cow and bull to reach equivalence with the same cuts from prime animals.
3. Opportunity to upgrade lower value cuts to higher value.
4. Use the concept to generate whole muscle tissue products
5. Reduce ageing times for current high value cuts

This initiative was therefore strongly supported by the industry and the objective continued to receive funding.

Project evolution

Laboratory based techniques:

Early bench-top systems utilised a clamping technique to stretch muscle samples (Exp tech 1). The device developed for this is shown in photo left. The meat quality benefits resulting from this were reported as an *ICOMST paper*[1].



Following from this, stainless steel tubes were then used to encase samples of LD (Exp tech 2) that were then tightened to compress and lengthen the muscle (see photo left). Again, this was a bench based technique and the effects on meat quality and sensorily measured texture were quantified (see data towards the end of this document). Some of the results from these trials were also used for a poster that was shown at a M&WNZ *Fieldays meeting*[2] This poster also included opportunities to use the basic techniques to reform and upgrade lower value cuts

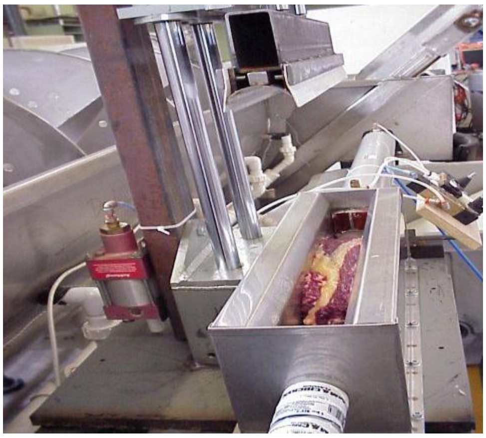
Upscaled/engineered devices:

Following these laboratory trials, a series of units were engineered to enable potential commercial options for the stretching and reforming of pre-rigor meat to be trialed. These are summarised below:

- Cut extrusion device
- Meat Roller
- The Don/Anzac

1. Cut Extrusion Device

The photo shows the cut extrusion device. This device was based upon putting the cut into a mould and then applying pressure from above. As the pressure was applied, the cut was stretched along the full length of the mould.



It was possible to get a high level of stretch on both cube rolls and striploins using this device (see photo above), but unfortunately, both cuts could be damaged during the process (see photo right). The damage took the form of fibre separation and this could occur in both the superficial areas and on occasion throughout the deep tissues of the cut.

However, despite these problems, this device could be used to successfully bind small pieces of pre-rigor meat together without the use of binders. The resulting ‘sausage’ of bound whole meat tissue was aesthetically very pleasing and held its form during grilling (see photo left).

Despite the opportunity to use this device to bind meat pieces, it was still necessary to develop a pre-rigor stretching device that would not damage the meat. Discussions between meat scientists and engineers led to the development of the meat roller (photo below). The meat roller wrapped the meat under tension. This was achieved by having a lower belt that moved in a clockwise direction while an upper conveyor moved in an anti-clockwise direction. The packaging material was applied around the cut, being kept taut by means of a brake so that the stress was continuously applied to the cut as it was wrapped.

This device was successful in stretching cube rolls, striploins and some rumps without damaging them. The meat quality after stretching with the meat roller was compared with the meat quality produced by the Pi-Vac technology the meat roller generated higher levels of stretch and improved meat quality when compared to unstretched controls and meat that had been through the Pi-Vac system (see data below).

The picture left shows a cube roll that has been stretched and packaged using the meat roller technology.

Industry Feedback
Prior to any further work on this experimental prototype, a selection of NZ processors who run hot-boning plants were asked to look at the unit and comment on it's potential application in their respective plants. While all members of this group were supportive of the concept of stretching and reforming meat, they felt that this particular device would not have commercial uptake due to the large amounts of packaging material required to process one cut (approximately 1 meter per cube roll) and the problems with cleaning and maintaining the sanitary state of it.

2. The Don/Anzac
In an effort to overcome these problems, the Don/anzac was designed by the engineers at AgResearch MIRINZ Centre. This device was based upon the following:

- Three steel chamber tapers that decreased from 160mm to 63mm (small tube), 75mm (medium tube) and 100mm (large tube).
- A button that shuts the chamber after pre-rigor muscle is loaded.
- A valve to allow air into the chamber at up to 100psi to force the muscle down the taper and into a parallel tube.
- A sensor on the parallel tube that tells the electronic controller that the meat has entered the parallel tube.

Work with this device demonstrated that it could be used to stretch cube rolls, eye rounds, flats and corner cuts with the level of stretch at between 27 and 80% of rest length depending upon the cut.

The Don/Anzac improved the shape of all the cuts, as seen in the photograph left. On the LHS is an unstretched flat (biceps femoris) while RHS sample is a flat that has been through the Don/Anzac.

Despite these positive results, some level of damage to some of the cuts was evident. As with the extrusion and rolling device, the damage was largely a parting of muscle bundles with tearing across the fibres occurring in the larger cube rolls where the end of the cut had curled back during the stretching process. This physical damage also occurred when the muscle sizes were not matched to the correct sized tubes – this resulted in overstretching and the damage described above.

Industry demo of the Don/Anzac

In June of this year, The Don/Anzac was demonstrated to ten representatives from two of the major hot boning Companies in New Zealand. While the unit successfully demonstrated the stretching of eye rounds and large cuts from the flap, it was generally felt that the footprint of this unit was too large to be easily accommodated in the majority of hot-boning rooms. Furthermore, to make full use of any commercial unit, it would be necessary for one pipe or tube to accommodate a variety of cuts rather than have tubes that are dedicated to one cut size. Past experience has shown that this would not be possible without compromising the level of stretch and damaging some of the cuts. Therefore, in summary, it was felt that while the overall concept behind this unit was reasonable, some significant modifications should be incorporated into the design and build of a commercial prototype.

3. Enter The Boa

The design of the commercial prototype or Boa, is based on air being forced into an outer sleeve of stretching cylinders with the meat cut encased in a flexible food-grade based silicon. As air is forced in, the inner sleeve decreases in diameter and increases in length, thereby stretching the meat within. Once the dimensions of the meat have reached the desired level, the active sleeve is squeezed together at one end, expelling the meat cut upwards into a metal tube. The meat is then expelled from the tube into the appropriate size tube of packaging.

The Boa is a compact unit that can be easily sited in most boning rooms. It is totally encased in a stainless steel cabinet and can be readily cleaned as part of the standard clean-down procedure.

<u>Operation steps</u>

1.*Inserting the meat to be stretched and formed*. For this operation, a partial vacuum is applied between the cylinder and the sleeve. This causes the sleeve to expand outward towards the sides of the cylinder, so increasing the aperture of the sleeve. This allows the meat cut to be dropped into the sleeve.

2. *Stretching and forming.* For this step, a positive pressure is applied between the cylinder and the flexible sleeve. This has the effect of compressing the meat and forcing it to elongate along the axis of the cylinder. Because the silicon material of the sleeve is flexible, the sleeve stretches with the meat: this avoids the build up of stresses in the meat caused by friction between the meat and the cylinder wall thereby reducing the risk of damage to the meat.

3. *Ejecting the meat*. a hollow metallic sleeve is pushed into the unit from above, and this is used to slide the meet into the sleeve. Manual tests of this concept were successful and this approach offers clear benefits: different cut sizes can easily be accommodated by changing the diameter of the metallic sleeve; and, once the sleeve is retracted, it can be used to transfer the stretched meat to the packaging system. .

Commercial trial

The Boa was installed into the Greenlea Hamilton hot-boning plant. It was not integrated with the packaging line to avoid any risks of hold-ups. However, a range of cuts were brought to the Boa and the performance of the equipment evaluated in consultation with the plant personnel. The equipment was shown to work well and could operate at line speeds if the range of cuts were limited to 3-4.

Cube rolls and eye rounds of a variety of sizes were stretched while the Boa was operating at Greenlea. Past work has shown that the cube roll cut is the most prone to tearing using the earlier stretching devices. Even with maximal positive pressure applied to the sleeve, no evidence of damage to the cube rolls could be detected.

An example of an eye round stretched using the Boa is shown above.

The next step is to develop an automated packaging system and then the Boa will be ready for further commercial trials as outlined in the 06/07 milestones.

Meat quality results

- A selection of results from some of the previous trials using the various experimental stretching units as stated in titles

1. Experimental method using stainless steel tubes to stretch

1.1 objectives MQ measurements from the cube roll

1.1.1 Mean sarcomere lengths for each level of pre-rigor stretch

Stretch (% rest length)	Mean sarcomere length (µm)
0	1.79[a]
20	2.67[b]
40	3.31[c]
Significance	***

The shear force values were significantly lower in both the 20 and 40% treatments compared to the controls after 1 and 3 days of ageing, although there was no difference in shear force values between 20 and 40% treatments.

1.1.2 Effect of pre-rigor stretching of beef cube rolls on shear force (kgf) after different periods of chilled storage

	Level of pre-rigor stretch (% of rest length)			
Storage time (Days)	control	20%	40%	Significance
1	13.0[a]	10.6[b]	9.9[b]	*
3	9.7 [a]	6.8 [b]	6.7 [b]	*
5	6.2	5.8	6.0	NS
7	5.3	5.5	6.5	NS

1.1.3 Effect of pre-rigor stretching cube rolls on fluid losses from meat samples, measured at different times and expressed as a % of original weight

	Level of pre-rigor stretch (% of rest length)			
	Control	20	40	Significance
Pre-rigor drip	0.32[a]	0.85[b]	0.96[b]	*
Post-rigor drip	1.53[a]	1.00[b]	1.02[b]	***
Cook loss	23.01[a]	19.74[b]	18.93[b]	***

6.1.1 1.1.4 Impact of stretching on colour stability

After 1 and 3 days of chilled storage, there was no affect of stretching treatment on colour stability. However, after 5 and 7 days chilling, the stretched samples had a shelf life of 7 days compared to the controls with a shelf life of 5 days, based on a* and hue values (data not shown)

***1.2. Evaluating the effect of stretching pre-rigor cube rolls using experimental stainless steel tube procedure (Exp Tech 1), on textural changes and objective MQ measurements*.**

1.2.1. Summary

The sensory component involved two treatments – a control and a stretch of between 20 and 40%. Both cube rolls were removed from 12 animals with one cube roll being used as a control with the corresponding muscle from the same animal being stretched to between 20 and 40%. All muscles were exposed to an AC&A chilling regime involving 12 hours at 10°C followed by a further 6.5 days aging at -1°C.

Four sessions consisting of 6 panelists in each were held to establish whether or not textural attributes could be distinguished between the control and the stretched treatment and whether these differences were favourable. The textural attributes the panelists were looking for were firmness/softness, initial juiciness, denseness, tenderness cohesiveness, fibrousness, cohesiveness of mass, sustained juiciness and chewiness.

The panelists were presented with 6 samples in each session, 3 controls and 3 treatments. These samples were randomly assigned to random generated numbers and cooked to an internal temperature of 75°C, patted dry, trimmed and presented to the panelists in bite size portions.

The results from the sensory evaluation show that the stretch treatment resulted in meat that was more firm ($p \leq 0.001$), had greater initial juiciness ($p \leq 0.001$), was less dense ($p \leq 0.001$), more tender ($p \leq 0.001$), less cohesive ($p \leq 0.001$), less fibrous ($p \leq 0.001$), had decreased cohesiveness of mass ($p \leq 0.001$), improved sustained juiciness ($p = 0.01$), and was less chewy ($p \leq 0.001$). The same samples were then fed to a selection of the staff at MIRINZ (treated as representative consumers) who felt generally that the stretched samples had a more acceptable texture than the unstretched control samples.

Objective measures using Tenderometer, myofibrillar fragmentation index and cook loss demonstrated similar responses to stretching. All the changes produced by pre-rigor stretching of the cube roll were favourable and demonstrate that the treatment enhanced eating quality

1.3. Effect of stretching pre-rigor the three major muscles of the rump using the stainless steel sleeve apparatus (Exp tech 1).

Effect of pre-rigor stretching on the shear force of the 3 major muscles of the rump

	Muscle								
	BF			GM			TF		
	Ageing period (days)			Ageing period (days)			Ageing period (days)		
	1	3	10	1	3	10	1	3	10
C	10.7[a]	6.5[a]	4.2	11.0[a]	6.7[a]	5.2	12.8	10.4	7.2
20	9.5[b]	6.5[a]	4.4	9.7[b]	6.1[a b]	5.3	13.8	10.7	7
40	9.5[b]	6.8[a]	4.6	9.1[b]	6.3[a b]	5.3	11.8	8.7	8.9
60	9.7[b]	5.1[b]	4.9	6.7[c]	4.5[c]	5.3	10.1	9.8	7.
80	9.3[b]	7.3[a]	4.8	8.8[b]	5.9[a b]	5.9	10.9	10.2	8.1
Sig	*	*	ns	**	*	ns	ns	ns	ns

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2. The effect of pre-rigor stretching using the extrusion device (2) and different chilling regimes on MQ.

The data from this work demonstrates that once the muscles have been stretched, different chilling regimes do not produce significant effects on shear force, colour stability or cook loss. In contrast, drip loss during ageing is significantly higher from stretched muscles chilled at 0°C compared to those chilled at 14 hours at 10°C then 0°C and those chilled for 4 hours at 15°C then 0°C

3. Comparison between the Meat Rolling device and the German PiVac system on MQ outcomes.

The existing rolling and stretching prototype was compared with the German PiVac moulding technology which has recently arrived in New Zealand.

Trial 1- To test the effects of the two units on the shear force of cube rolls.
Twenty pre-rigor cube rolls were hot boned from 10 prime carcasses from a local plant. Each cube roll was cut into three equal portions and assigned to either a control, Meat roller or PiVac treatment, according to a randomized block design. The level of stretch generated by the meat roller and PiVac units was measured, and the samples were placed at 15°C overnight before cutting into three equal portions, and ageing at -1°C. After 3, 5 and 9 days, the cooked shear force was measured.

Unfortunately, despite the fact that electrical stimulation was not used on these carcasses, many of the samples were at or close to rigor when they arrived back at the MIRINZ Centre, and this limited the extent of stretch that could be produced by the treatments. However, despite this, the average amount of stretch generated by the PiVac unit was 11%, compared to 20% for the meat roller unit ($p<0.05$). After 3 days of ageing, the shear force values from the PiVac and meat roller treatments were lower than the control samples, although these tenderness differences did not quite reach significance ($p = 0.057$). After 3 and 9 days of ageing, the effect of treatment was not significant, although the meat roller treatment had lower shear force values at each time point (see Table below).

Table 1. Effect of treatments on shear force of cube rolls after ageing for different periods. Values given are means (standard deviation)

	3 days	*7 days*	*9 days*
Control	*6.85 (2.61)*	*5.91 (1.55)*	*6.23 (1.39)*
Meat roller	*6.04 (1.22)*	*5.37 (1.15)*	*4.89 (1.31)*
PiVac	*6.02 (1.21)*	*5.85 (0.86)*	*5.16 (0.95)*

The effect of stretching and moulding was limited due to the rapid rate of rigor onset in these muscles, and this is reflected both in the degree of stretch and the subsequent shear force values. However, despite the fact that the control cube rolls tenderized very rapidly due to the rapid rate of pH fall and the relatively slow chill during the first 24 hours, there was clearly an additional level of tenderizing conferred by both the meat roller and PiVac treatments. While this did not quite reach significance, the trend was for these treatments to be more tender when compared to the controls and this effect was greatest in the meat roller samples. Furthermore, both stretching treatments tended to reduce the range of shear force values compared to the control samples, and this effect was particularly noticeable when ageing was minimal at 3 days post-mortem. This finding has been a feature of past work under this objective and suggests that stretching and forming pre-rigor meat can help to overcome some of the tenderness variability that is always evident in unaged or partially aged meat.

Trial 2 – To test the effects of the Meat Roller and the PiVac system on the shear force of eye of rounds.
Ten eye round cuts were hot boned from 5 prime carcasses from a local plant. These were treated in a similar manner to the cube rolls, and were aged for either 1 or 9 days.
The level of stretch generated was measured at an average of 25% for the PiVac treated samples and 40% for the meat roller treated samples. Generally, the pH was slightly higher at the time of stretching compared to the cube rolls, and thus the level of stretching was more consistent across the samples. However, past work has shown that the eye cuts tend to stretch to a greater level than cube rolls due to their longitudinal fibre arrangement and high elastin content, irrespective of the pH at the time of stretching. After 1 day of ageing, the shear force values from the meat roller and PiVac treated eye of rounds were lower than the controls, although these differences did not reach significance, and, after 9 days, these differences were no longer evident (see Table 2). However, as with the trial detailed above, the stretching and reforming treatments reduced the variability in shear force after both 1 and 9 days of ageing.

Table 2. Effect of treatment on shear force of eye of rounds after ageing for different periods. Values given are means (standard deviation)

	1 day	*9 days*
Control	*13.91 (2.12)*	*7.30 (1.73)*
Meat roller	*12.61 (1.96)*	*7.48 (0.27)*
PiVac	*14.33*	*7.39*

	(1.92)	*(0.61)*

Trial 3 - To test the effects of the meat roller and PiVac treatments on the colour stability of cube rolls after ageing for 5 days and 4 weeks
Ten cube rolls were hot-boned from 5 prime carcasses from a local plant. The cuts were returned to the MIRINZ Centre, and cut into three pieces, as with the previous trials, and assigned to a treatment group according to a randomized block design. The level of stretch generated by the meat roller and PiVac units was measured, and the samples were placed at 15°C overnight before cutting into two equal portions, vacuum packing (controls and meat roller samples only), and ageing at -1°C. After either 5 days or 4 weeks, the samples were cut into steaks, put into a retail overwrap pack and put in a retail display cabinet running at 2°C. The colour deterioration during simulated retail display was recorded using a Hunterlab Miniscan, and colour readings were taken daily from each sample for a total of 16 days.
The pre-rigor pH values at the time of stretching were generally slightly higher than in trial 1, and this is reflected in the higher level of stretch that was generated by the meat roller (average stretch 25%), although there was little change in the stretch produced by the PiVac unit (11%) compared to trial 1.

The colour changes in samples that had been aged for 5 days prior to the 16-day simulated retail display show that there was very little difference in the rate of colour deterioration between the three treatments. There was some difference in the hue angle (indicator of colour change from red to brown) by days 8 and 9 with the control samples having slightly higher hue values compared to both the meat roller and PiVac treatments (36.8 vs 33.9 and 34.5 respectively), although these differences did not reach significance (data not shown). Similarly, the control samples tended to be slightly brighter (higher chroma values) and slightly more yellow (higher b* values) than both the meat roller and PiVac treated samples throughout the 16-day simulated retail display period, although again, these differences did not reach significance.

3. The Don/Anzac – The effect of stretching using The Don/Anzac on appearance and objective meat quality

Effect of stretching on the physical appearance of steaks
The level of stretching achieved for all the muscles ranged from 43-97%. The level of stretch in the 3 muscles were in the order ST (97.1) > SM (77.9) > BF (43.7), suggesting that higher level of stretch was achieved with muscles having fibres aligned parallel to the length of the muscle (ST and SM) than muscles with mix fibres (BF). Stretching reduced the size of the steaks and improved uniformity, presentation and portion control (Fig. 2).

When muscles were stretched using the right tube size, there were no observed physical defects. Some of the physical defects observed include muscle fibre bundle damage, breakage of fibres in muscles with fibres running parallel to the direction of stretch (ST & SM), gaping and failure to maintain shape uniformity particularly in fatty areas in muscles with fibres running in different directions along the stretch (BF). This physical damage is caused due to failure to match muscles to the right stretching tubes resulting in overstretching and other physical defects.

Effect of stretching on meat quality attributes
Stretching the muscles pre-rigor improved the tenderness and reduced the drip loss significantly at all storage periods (Table 1). Stretching did not affect the colour of the meat but increased the amount of moisture loss during cooking (Table 1). The reason for the higher cook loss in stretched muscles is because raw stretched muscles had higher free moisture due to less drip and on cooking more of this moisture is lost in the stretched muscles compared to control. The opposing effect of stretching on drip and cook loses suggest physical rather than biochemical factors were responsible for the difference between control and stretched muscle. Higher cook loss is less likely to affect merchandising of stretched steaks. The most important attributes that determine acceptability at the point of sale such as colour or visible drip have either been improved or not affected by stretching, and tenderness – being the most important attribute that affects acceptability of cooked meat – has been improved by stretching

Table 1. Effect pre-rigor muscle stretching on changes in meat quality attributes with storage time

Quality Attribute	Rigor		24 hrs		48hrs		72 hrs		120		*P* level
	C	S	C	S	C	S	C	S	C	S	
pH	5.46	5.50	5.50	5.48	5.49	5.48	5.47	5.45	5.37	5.33	0.06
Drip loss, %	ND	ND	2.2	1.6	3.1	1.7	3.9	2.4	6.6	3.1	0.001

Tenderness, KgF	10.3	9.2	8.1	7.7	8.1	7.0	7.9	7.0	7.3	6.8	0.001
Cook loss, %	ND	ND	28.2	32.6	24.7	30.5	26.4	28.3	33.4	37.6	0.001
Colour, a*	18.7	18.5	18.6	17.8	17.9	16.9	15.6	14.9	14.5	14.0	ND
P level = Statistical significance of storage time on the attribute; C = Control; S = Stretched; ND = Not determined											