Final report

Pre-rigor manipulation to enhance meat quality

Project code: P.PSH.0322

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Date published: December 2008

PUBLISHED BY
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This is an MLA Donor Company funded project.

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

Abstract

Controlling quality attributes of red meat 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 (legs vs loin, for example).

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 current pre-production prototype Boa unit works as follows:

- Meat is inserted into a rubber sleeve and pressure is applied to squeeze the meat out.
- Pressure is applied in two stages; firstly via four inflatable bags located internally (behind the rubber sleeve) and secondly via pressure applied to the rubber sleeve itself.
- As the meat is squeezed it is expelled into packaging sleeve that has been located directly above the opening of the rubber sleeve.
- The meat is maintained in the packaging during the onset of rigor mortis and subsequent storage thereby ensuring the stretch and shape of the product is maintained throughout.

The Boa unit, as described above, was trialled recently in a beef hot boning plant. The findings and meat quality results are reported in the current project.

The following process steps was applied:

1) Develop operating protocols
2) Submit full patent specification
3) Pilot trials and evaluation of meat quality
4) Consumer evaluation, and
5) Commercialisation guidelines and initial considerations

With regard to the Boa technology it has been shown that it can be used to improve the tenderness of hot-boned loins to a similar level as other stretching technologies on cold-boned carcasses. In addition, it has been shown that manipulation of the chilling regime was far more flexible than the chilling regime of intact carcases. Future research may be aimed at increasing the level of stretch achieved with this technology and determining the optimal chilling conditions. In addition, this technology might be tested to improve the tenderness of muscles that are not affected by stretching techniques on intact carcasses.

Further research and development is proposed to bring the prototype Boa unit to market & determine appropriate commercial adoption pathways.

Executive summary

Controlling quality attributes of red meat depends substantially on manipulation of the temperature and pH decline after slaughter. 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 (legs vs loin, for example). Muscle tissue extracted using hot boning methods, 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.

A production prototype unit (i.e. Boa) has been developed to manipulate hot boned muscle tissue in such a way as to avoid the sacromeres from shortening during the onset of rigor. The current Boa unit works as follows: Meat is inserted into a rubber sleeve and pressure is applied to squeeze the meat out. Pressure is applied in two stages; firstly via four inflatable bags located internally (behind the rubber sleeve) and secondly via pressure applied to the rubber sleeve itself. As the meat is squeezed it is expelled into packaging sleeve that has been located directly above the opening of the rubber sleeve. The meat is maintained in the packaging during the onset of rigor mortis and subsequent storage thereby ensuring the stretch and shape of the product is maintained throughout.

The Boa unit, as described above, was trialled recently in a beef hot boning plant. The findings and meat quality results are reported in the current project.

The specific objectives of the research were:

- Complete the construction of the equipment / technology to meet requirements for a commercial operation;
- Commercial pilot trial in at least one New Zealand plant and one Australian beef processing operation;
- Benchmarking of selected cuts to identify benefits of pre-rigor stretching;
- Investigate pre-prigor effect of *Bos indicus* and *Bos Taurus;*
- Evaluate and report on the performance of the technology in a commercial operation for cold- and hot-boned processing applications; and
- Pass the technology onto the commercialiser.

To enable commercial users to operate the technology and also to provide potential commercialisers with information on the working of the Boa, a comprehensive set of operating protocols and trouble-shooting guide has been compiled. This document was designed to cover the working operation of the initial meat stretching prototype device (i.e. Boa) first developed in NZ in a pilot laboratory setting, as it currently stands as at October 2008.

This document would require upgrading as the Boa technology and the associated components are developed during the MQST 08-09 programme.

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1. Background and description

1.1 Project background

Tenderstretch hanging of carcasses is used to substantially improve the palatability of hindquarter cuts in both beef and lamb. The magnitude of the tenderstretch advantage is generally greater in poorer quality carcasses, being carcasses from *Bos Indicus* cattle which show a reduced aging response in, for instance, the loin. The effect of tenderstretch is thought to be largely through reducing the toughening effect of muscle shortening at rigor, thereby acting as an insurance against the effects of cold-shortening and heat-shortening conditions (Thompson et al., 2005).

Previous studies have shown that pre-rigor stretching of muscle beyond sarcomere lengths of about 2µm was unlikely to result in a significant increase in tenderness (Marsh and Carse, 1974). Tenderstretching increases sarcomere length in the striploin to about 2µm, but there is variation about this value and hence, whilst there is a general improvement, there is still some variation in the tenderness of tenderstretched striploins. In previous Beef CRC studies, up to a 5 fold reduction in variance of tenderness was observed as a result of tenderstretching (Thompson et al., 2006). Therefore, it is possible that stretching beyond a sarcomere length of 2µm may result in a further decrease in tenderness variance, thereby lessening the reliance on a good ageing response to produce a uniformly tender product. In addition, stretching may improve the water-holding capacity of meat, given the relationship between drip loss and sarcomere length (Honikel et al., 1986).

With conventional chilling, carcasses are often exposed to high rigor temperatures which are known to denature µ-calpain and, therefore, reduce potential post mortem proteolysis and tenderisation of meat. Therefore, interventions in the slaughter/chilling process that would combine pre-rigor stretching and rapid chilling may result in substantial improvements in tenderness. The Boa technology provides this opportunity. This technology consists of applying pressure on pre-rigor meat and thereby stretching it. The stretched meat is thereafter extruded into a plastic casing which prevents contraction of the stretched muscle. In addition to improving tenderness, it offers the possibility to standardise primal shape, and therefore, steak size and shape.

The net result of pre-rigor stretching combined with moulding and rapid chilling may provide a substantial improvement in tenderness with low drip loss and a standard steak size and shape. These advantages could produce a product suitable for a niche market such as the restaurant trade or a retail product which attracts a substantial price premium.

Controlling quality attributes of red meat 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 (legs vs loin, for example).

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 current Boa unit works as follows: Meat is inserted into a rubber sleeve and pressure is applied to squeeze the meat out. Pressure is applied in two stages; firstly via four inflatable bags located internally (behind the rubber sleeve) and secondly via pressure applied to the rubber sleeve itself. As the meat is squeezed it is expelled into packaging sleeve that has been located directly above the opening of the rubber sleeve. The meat is maintained in the packaging during the onset of rigor mortis and subsequent storage thereby ensuring the stretch and shape of the product is maintained throughout.

The Boa unit, as described above, was trialled recently in a beef hot boning plant. The findings and meat quality results are reported.

1.2 Project description and expected outcomes

To enable commercial users to operate the technology and also to provide potential commercialisers with information on the working of the Boa, a comprehensive set of operating protocols and trouble-shooting guide has been compiled. This document was designed to cover the working operation of the initial meat stretching prototype device (i.e. Boa) first developed in NZ in a pilot laboratory setting, as it currently stands as at October 2008. This document would require upgrading as the Boa technology and the associated components are developed during the MQST 08-09 programme.

The desired outcomes of the current research were:

i) New technology

- The pre-production prototype for stretching hot boned meat will be developed.

ii) Project Intellectual Property:

- Technology for stretching hot boned meat.
- Shared between MWNZ and MLA.
- IP is shared between MLA and MWNZ, on the condition that MIRINZ Inc will be acknowledged in any media release or public statement concerning the results of the MLA / MWNZ collaborative research programme.

iii) Commercialisation/Dissemination Strategy:

- Technology to be kept confidential until patent is obtained. Technology to be passed to commercialiser when ready.

2. Objectives

The overall aim of the project was to evaluate a working prototype meat stretching device. The specific objectives of the research were:

- Complete the construction of the equipment / technology to meet requirements for a commercial operation;
- Commercial pilot trial in at least one New Zealand plant and one Australian beef processing operation;

- Benchmarking of selected cuts to identify benefits of pre-rigor stretching;
- Investigate pre-prigor effect of *Bos indicus* and *Bos Taurus;*
- Evaluate and report on the performance of the technology in a commercial operation for cold- and hot-boned processing applications; and
- Pass the technology onto the commercialiser.

3. Methodology

The following process steps was applied:

- Develop operating protocols (Milestone 1)
- Submit full patent specification (Milestone 2)
- Pilot trials and evaluation of meat quality (Milestone 3)
- Consumer evaluation (Milestone 4)
- Commercialisation guidelines and initial considerations (Milestone 5)

3.1 Develop operating protocols (Milestone 1)

Develop operating protocols covering trials and subsequent market performance/feedback information with minimum of two Australian and two New Zealand beef processing operations and the commercial partner(s) including cold- and hot-bone processing applications. The progress report (Milestone 1) to be submitted to the MLA and MWNZ project steering group for approval.

A critical decision point (i.e. Go / No Go point) by the MLA and MWNZ project steering group was reviewed on the basis of successful completion of the initial milestone (to develop operating protocols) to deliver:

- Appoint commercialiser, and
- Preliminary impact & feasibility analysis complete.

3.2 Submit full patent specification (Milestone 2)

A full patent specification was drafted and submitted for approval (See Appendix, See Section 9.2).

3.3 Pilot trials and evaluation of meat quality (Milestone 3)

3.3.1 Meat quality (New Zealand) trials

The aim of the current milestone 3 was to report on in-plant activities, meat quality evaluations and product performance from trials in collaboration with a host plant on post-rigor meat, including conclusion of phase 2 of the *Bos Indicus* and *Bos Taurus* benchmarking trial.

i) Sample preparation:

The immobilisation and stimulation applied during the processing of the carcasses was modified to ensure the pH fall was optimal for the subsequent stretching and reforming treatment.

Once the carcasses had been railed into the boning room, the left and right sides of 5 commercial cuts from 6 prime beef carcasses were selected (approximately 45 minutes following slaughter). One cut, (or a portion of each cut if too large to go into the packaging material), from each side was immediately packaged using the Boa technology and the contralateral cut was vacuum-packaged using the standard procedures employed at this plant (control). Thereafter, the product was placed in cartons and, after following the plants' usual carton chilling regime, was then held chilled (-1°C) for meat quality assessments after 3, 7 and 14 days of storage.

The five muscles selected were:

- Cube roll (cap-off) *longissimus dorsi*
- Tritip – *Tensor fascia latae*
- Topside - *Abductor*
- Topside - *Semimembranous*
- Outside flat – *Semitendinosus & Gluteobiceps*

Assessments and meat quality evaluations consisted of:

- Shape formation and degree of stretch
- Fluid losses (cook loss, suspension drip, water binding capacity - WBC)
- Ultimate pH
- Tenderness (shearforce)
- Colour stability (7-day simulated retail display)

ii) Shape and Stretch

The shape of each meat cut, after packaging through the Boa, was assessed for acceptability in terms of appearance and maintaining shape during storage. The cut dimensions before and after Boa treatment were measured and the approximate degree of stretch calculated.

iii) Purge Losses

Cook loss was measured from samples that were cooked prior to shear force testing.

Water-binding capacity (WBC) was measured in duplicate for each sample. A 0.5g sample was accurately weighed onto filter paper and squashed between two Perspex plates in a press for 1 minute. An image of the resultant areas of purge was taken and the area of water expelled was measured and calculated using digital imaging software (i.e. ImageJ).

Fluid loss was also measured on a sample from each of the cube rolls using a suspension drip method. A portion of meat was weighed, placed in a nylon bag and the meat plus nylon bag were contained within a plastic bag. The bag was filled with air to prevent it making contact with the meat sample and then the bag was suspended on a purpose-built frame thereby allowing the drip to accumulate in the bottom of the polythene bag. All samples were suspended in this way in a chiller for 72 hours. After this time, the meat samples were removed from the nylon and polythene bags and re-weighed. The fluid lost was expressed as percentage.

iv) pH and Tenderness

The ultimate pH was measured using a stab probe on the samples just prior to cooking. The shearforce was measured using the G2 digital tenderometer.

v) Colour Stability

The colour was measure daily for 7-days using a colour-meter (Minolta CR 400). Steaks were placed on black polystyrene food trays, overwrapped and held in a chiller at 5°C to simulate retail display. Additionally, steaks were weighed before and after retail display to calculate fluid losses.

3.3.2 Australian pilot processing trials

The Australian component of the meat stretching evaluation “Utilising the Boa stretching technology to improve the quality of hot boned striploins” was undertaken by UNE (Dr Geert Geesink and Professor John Thompson). The current report describes the effects of application of the Boa technology on meat quality characteristics of the striploin as compared to cold-boned striploins from achilles tendon hung carcasses and carcasses subjected to tenderstretching or superstretching.

i) Animals and treatments

A total of 60 beef carcasses were selected from domestic grain fed cattle over two consecutive days (30 each day) at ACC in Brisbane. Striploins from 60 carcasses were hot-boned and subjected to pre-rigor stretching using the Boa technology. Corresponding carcass sides were assigned to one of three suspension treatments, including achilles tendon (AT), tenderstretching (TS), or superstretching (SS). Boa treated samples were further allocated to either rapid chilling in an ice bath (BI), or moderate chilling (BC). Samples were aged for different periods and the meat quality evaluated.

Animals were slaughtered according to the usual procedures. The selection criteria for the animals was that they originated from one feedlot, were females and had a maximum dentition score of 2. All carcasses were MSA graded. Summary statistics of the carcass grading traits are given in Table 1.

Table 1: Summary statistics of carcass traits.

Trait	Mean	S.D.	Min.	Max
Hot carcass weight (kg)	215.2	10.7	200.6	240.7
P8 fat (mm)	8.2	2.8	4.0	15.0
Rib fat (mm)	5.5	2.0	2.0	11.0
Eye muscle area (cm^2)	51.8	5.4	40.0	67.0
Hump height (mm)	92	20	55	150
US marbling score	225	80	120	450
Ultimate pH	5.53	0.1	5.40	5.73

In the first 8 h post mortem (knocking time was recorded), a total of 5 time, pH and temperature measurements were recorded at the 12th rib junction in the intact carcass side or at the anterior side of the Boa treated samples. The following day, the ultimate pH was measured at the same sites.

For the Boa treatment, the longissimus muscle (from the 10th rib to tuber coxae) was excised from the hot carcass, trimmed of subcuteaneous fat, and subjected to the stretching treatment using the Boa equipment. The proportion of stretch resulting from Boa the treatment was estimated by measuring the length of the muscle samples before and after the treatment.

At 1 day post mortem the longissimus muscles was excised (10^{th} rib to tuber coxae) from the intact carcass sides. For all samples, three 7 cm long samples were taken, starting at the anterior end of the muscle, vacuum packed, and randomly allocated to aging (1°C) for 1, 7 or 21 days. Samples were frozen at -20°C after their respective aging periods.

While still frozen, samples were subdivided for the different measurements.

- The first 1 cm slice from either the anterior or posterior side was assigned to colour stability measurements using the Minolta colour meter on the freshly cut surface
- The second 1 cm slice was assigned to thaw loss measurements.
- The first lateral slice (0.5-1 cm thick) off the remaining sample, was discarded and the second lateral slice of 0.5-1 cm was assigned to determination of sarcomere length.
- The third lateral slice (0.5-1 cm thick) was assigned to particle size analysis.
- From the remaining sample, a subsample of about 4x4x5 cm was cut for determination of cooking loss and shear force. All subsamples were kept frozen at -20°C until analysis.

ii) Shear force and cooking loss

Cooking loss and shear force were determined as described by Perry et al. (2001) with minor modifications. These modifications were the dimensions of the samples (4x4x5 cm), the cooking time (35 min.), and that the samples were cooked from the frozen state.

iii) Sarcomere length

Mean sarcomere length at 1 day post mortem was determined on 12 slices from each sample, using a Helium-Neon laser diffraction technique according to the method described by Cross et al. (1981).

iv) Colour stability

One cm thick steaks were placed in polystyrene trays and covered with oxygen permeable plastic foil. L*-, a*-, and b*-values were recorded using a Minolta CR-300 Chromameter after 1, 2, 3, 4, 5, and 9 days of storage at 3°C. The light source of the colour meat was D65 and the instruments was calibrated on a white tile according to the manufacturer's specification.

v) Thaw loss

While still frozen, samples of about 4x5 cm were cut from the centre of the steaks and their weights recorded. Samples were placed on stainless steel cake racks, thus allowing for free flow of fluid from the samples, covered with plastic foil, and left in the cold room (3°C) for two days. After two days, the samples were patted dry with paper and the weight was recorded. Thaw loss was expressed as the percentage weight loss over the two day period.

vi) Particle size analysis

Particle size analysis was performed according to Karumendu et al (2009). This analysis was performed the NSW DPI, Centre for Sheep Meat Development, Cowra, NSW. The results of this analysis will be reported on in a separate report by this organisation.

vii) Statistical analysis

Exponential rates of decline for pH and temperature were estimated using SAS (1999) by fitting pH and time and temperature and time to the following non-linear equation:

yt = xμ + (xi – xμ)-kt, where yt was pH, or temperature, as a function of time ; xμ ultimate pH or temperature; xi initial pH or temperature; k the exponential rate of pH or temperature decline; and t time.

Time at pH 6.0 was then calculated and used to estimate temperature at pH 6.0 (T@pH6).

Shear force and cooking loss were analysed using a mixed model (SAS, 1999) with fixed effects for treatment, ageing time and position a covariates for linear and curvilinear effects for ultimate pH and T@pH6. These analyses included a random effect for carcass number.

As thaw loss and sarcomere length were only measured on day 1 samples, the mixed model only contained terms for treatment and position, along with the covariates.

The Minolta colour dimensions (L*, a*, and b*) were analysed in a mixed model which included fixed effects for treatment, ageing, display time and position along with the covariates for pHu anf T@pH6. For all analyses, first and second order interactions were tested and no-significant interactions (P>0.05) interactions were discarded.

3.3.3 New Zealand pilot processing trials and meetings

Numerous documentation were reviewed and compiled over several years of working with pre-rigor stretching and reforming concepts and more recently the specific Boa technology (Refer to Tables 2 and 3). Several meetings were conducted with NZ plants at with industry representatives at Carne Technologies pilot facilities where the technology was demonstrated from a central location relevant to provide feedback on stretching and reforming concepts and processing methods.

Table 2: Meetings at Carne Technologies relevant to stretching and reforming concepts and technologies:

Date	Client	People	Details
06/06/2006	Meat Board	Directors	Demonstration of Stretching technology and product outcomes
23/06/2006	Riverlands ANZCO	Rob Archibald Wayne Fergus Ian	Demonstration and discussions on stretching concepts and potential commercial options
30/08/2006	Sheep Council Excecutive		Demonstration of stretching and reforming
18/09/2006	Greenlea Morrinsville	Tim Aitken (CEO)	Demonstration of Boa

		Russell Shaw (Manager – Morrinsville) Graham Green (Manager Hamilton) Neville Thompson (Chief Engineer) Richard Wills – Manager Marketing)	
21-23 May 07	MWNZ/MLA	Chanel Thomas Ian Richards David Carew Dean Gutzke	MQST update Boa trials Action plans for 07/08
13/09/2007	Foodchain	CEO - Nick Archibald	discuss MQ, Premium branding opportunities relating to pre rigor stretching concepts
17/10/2007	MWNZ	MIRINZ conference attendees	follow on from MIRINZ workshops to Carne discuss/view updates in meat science
25/02/2008	ANZCO Group	Steve Cartwright	Discussion on specific ANZCO requirements relating to pre-rigor stretching and reforming
22/10/2008	Alliance	Gary McLennan Sonia Lindsay	Discussion on Boa technology and opportunity to hot bone lamb and mutton
04/12/2008	MWNZ	Chanel Partridge Bernie Radford	Boa commercialisation

Table 3: Demonstrations and trials conducted at NZ Meat Plants using Boa technology.

Trials	**Meat Plant**	**Involved:**
Nov-Dec 06	Greenlea Morrinsville	Eye & cube roll, test other muscles
May 07	Greenlea Hamilton	Eye, cube, LD trialled
May 07	Carne	MQ trial + David Carew visit +MLA +MWNZ Triptip, outside, eye, cube
14-15 June 07	Riverlands Eltham	Meat quality trials & ANZCO product
Aug-Sept 08	Wallace Corporation (Waitoa)	MQ trial, storage trial

3.3.4 Feedback from past and present evaluations and public demonstrations

A series of sessions, public demonstrations and scientific presentations were delivered to provide feedback on the technology and product concepts. Specifically: presentation was delivered at the

- International Congress of Meat Science & Technology (ICoMST) – 1999, Yokohama, Japan - Poster presentation (paper attached)

- ICoMST Plenary paper presentation – 2006, Dublin, Ireland (meat science findings from pre-rigor stretching)
- Scientific paper, published in Journal of Meat Science 2006
- MWNZ Beef & Sheep Executive Council Meeting. Poster presentation (poster attached)

The progress report (Milestone 3) on in-plant activities, meat quality evaluations and product performance from pilot processing plant trials to be submitted to the MLA and MWNZ project steering group for approval.

3.4 Consumer evaluation (Milestone 4)

The sensory work was undertaken using a subset of samples from the UNE trial previously reported (150.05E Milestone 3).

Beef carcasses were selected from domestic grain fed cattle over two consecutive days (30 each day) at ACC in Brisbane, Australia. Animals were slaughtered and processed by the standard ACC procedures. The selection criterion for the animals was that they originated from one feedlot, were females and had a maximum dentition score of 2. All carcasses were MSA graded.

One side was randomly assigned to the Boa (BO) treatment, and the other to one of three suspension treatments, including achilles tendon (AT), tenderstretching (TS, hanging from the oburator forem), or superstretching (SS, using a pulley system to draw the tenderstretched hindlimb towards the forequarter). Therefore, for each carcass, the Boa treated sample from one side of the carcass was compared against the contralateral striploin that had been subjected to either AT, SS or TS.

Striploins were collected from a total of 43 carcasses and aged for 16 or 28 days before consumer responses were evaluated using the standard MSA protocols: Consumers were asked to score samples for tenderness (T), juiciness (J), flavour (F) and overall liking (OL). Scoring was carried out using a single sheet using four 100m line scales, which were anchored with the following words; T - very tough to very tender; J - very dry to very juicy; F and OL - dislike extremely to like extremely. Consumers were also asked to grade the samples for overall satisfaction (1-5 with 5 being highly satisfactory). The values for T, J, F and OL values from each consumer were analysed using a statistical model which effectively removes the outliers from these data and then generates an overall meat quality score (this is heavily weighted towards tenderness) - the 'clipped meat quality score or CMQ4.

In addition to the MSA testing, report on cooking procedures developed in consultation with MLA's David Carew for commercially significant cuts identified from commercial pilot trials (i.e. Milestones 1, 2 & 3). Conduct sensory and consumer evaluations on specified cuts using these developed cooking procedures. The progress report (Milestone 4) on cooking methods and sensory results to be submitted to the MLA and MWNZ project steering group for approval.

3.5 Commercialisation guidelines (Milestone 5)

Develop technology transfer documentation and guidelines including, specifications, data sheets, & materials to hand over to commercialiser on operation of commercial Boa technology for beef. Transfer documents to commercialiser(s) and provide information to assist in reviewing industryfocussed trade publication(s), specifically an industry bulletin on the use of the meat stretching prototype device (i.e. Boa technology).

A critical decision point (i.e. Go / No Go point) by the MLA and MWNZ project steering group was reviewed on the basis of finalising the proposal in consultation with prospective commercialiser, MLA and MWNZ for ongoing technical and marketing work on pre-production Boa prototype and submitted to Meat Donor Company (MDC) for potential ongoing next phases of development.

4. Results

4.1 Develop operating protocols (Milestone 1)

To enable commercial users to operate the technology and also to provide potential commercialisers with information on the working of the Boa, a comprehensive set of operating protocols and trouble-shooting guide has been compiled. Refer to Appendix (See Section 9.1). This document covers the working operation of the NZ Boa as it currently stands as at October 08. This document will require upgrading as the Boa technology and the associated components are developed during the MQST 08-09 programme.

4.2 Submit full patent specification (Milestone 2)

The full patent (See Appendix, Section 9.2) was submitted and approved as evidence by Figure 1.

Meat NZ Milestone Report

Project Code:	MQST (formerly 98MZ/MQ30)	**CT Accounting Code:**	
Milestone No:	2		
Project Title:	Pre-rigor manipulation		
Programme Title:	Meat Quality Science and Technology		
Milestone Description:	Submit full patent specification		
Milestone Date:	April 08		

Milestone Status:	Achieved

Milestone Completion Summary:
Background
Draft PCT patent has been completed and is with AJ Park

Report Attached:	No
Report No:	

Summary Circulation:	Confidential		
Report Circulation	Confidential		
Project Leader:	Nicola Simmons	**Date: May 08**	
Client Approval:		**Date:**	

Figure 1: Approved submission of full patent and specifications for pre-rigor manipulation.

4.3 Pilot trials and evaluation (Milestone 3)

4.3.1 Meat quality (New Zealand) trials

i) Shape formation

Different muscles required varying degrees of force to expel the meat from the Boa and, while the shape was successfully re-formed into the desired log shape generally, there was very limited, if any stretching. In all cases, the log shape was maintained after removal of the bag at the end of the required ageing period. Figures 2 and 3 show the cuts before and treatment with the Boa.

Figure 2: 'Control' cuts; Topside (top centre), Tritip (left), Cube roll (centre), Outside Flat (right).

Figure 3: Cuts from the Boa treatment, pictured from top to bottom; Topside (abductor), Topside (*semi membranosus* – half of the muscle), Outside Flat, Cube Roll, Triptip (left) and Topside (*semi membranous* - half of the muscle).

The shape of all cuts after treatment with the Boa was good and all product looked visually appealing. The appearance of the cube rolls and tritips was further enhanced due to the high level of marbling and subcutaneous fat seen clearly in and around the cut (Figures 4 and 4b).

Figure 4a and 4b: Cube roll (Left) and Tritop (right) after Boa.

Figure 5 shows the cube roll cut into steaks. A control sample is shown in the same picture for comparison (See Figure 5).

Figure 5. Cube roll cut into steaks; Control (top), Boa portions (bottom).

The other muscles were also effectively reformed; the following figures (6a,b and 7a,b) show muscles before and after pre-rigor manipulation.

Figure 6a and 6b. Tritip control samples (left) and Boa (right).

Figure 7a and 7b. Outside Flat muscle; controls (left) and Boa (right). Note: Boa sample is one triptip cut into thirds.

ii) Meat quality measurements

The ultimate pH of all cuts from both control and Boa treatment were within the range of 5.4 to 5.6. The mean values for the meat quality measurements after the 3 ageing timepoints, are shown in Table 4. Overall, there were no significant differences between the control and Boa samples for any of the attributes measured.

Table 4: Mean values for meat quality measurements.

Attribute	Muscle	Day 3		Day 7		Day 14	
		Boa	Controls	Boa	Controls	Boa	Controls
% Cook Loss	Cube Roll	26.2	24.9	27.2	27.4	29.5	26.9
	Outside Flat	31.3	31.0	31.7	30.8	34.8	31.8
	Tri Tip	28.6	29.1	28.8	28.5	-	-
	Topside Abductor	35.7	33.9	32.4	36.0	-	-
	Topside SM	31.4	32.6	34.0	34.0	35.8	33.7
Tendernes s (kgF)	Cube Roll	8.2	9.2	6.9	7.1	5.2	6.6
	Outside Flat	8.3	10.9	7.9	7.5	7.3	6.9
	Tri Tip	12.3	12.9	10.2	9.2	-	-
	Topside Abductor	10.1	10.2	9.4	7.9	-	-
	Topside SM	11.2	9.6	9.0	8.2	8.0	6.9
WBC area cm^2	Cube Roll	2.97	3.07	2.94	2.77	2.78	2.97
	Outside Flat	3.05	3.09	3.15	3.01	3.21	3.18
	Tri Tip	3.14	3.23	3.18	3.28	-	-
	Topside Abductor	3.01	3.21	2.80	3.12	-	-
	Topside SM	3.03	3.22	3.06	3.09	3.11	3.18
Suspension Drip %	Cube Roll	7.0	5.5	5.5	5.0	4.0	2.9
% Retail Drip	Cube Roll	1.4	0.7	1.0	0.9	0.8	0.9
	Outside Flat	1.0	1.3	0.8	1.1	0.7	0.8
	Tri Tip	0.5	0.1	0.5	0.4	-	-
	Topside Abductor	2.4	2.8	0.9	1.4	-	-
	Topside SM	2.2	2.6	1.1	1.5	0.9	0.8

i) Purge losses

Cook loss values were all within the normal expected range with an overall average of around 30-35%. There was a significant effect of storage on cook loss ($p \leq 0.001$) with longer periods of ageing resulting in more cook loss, but there was no significant difference between control and boa treated samples. Not unexpectedly, WBC tended to decrease with ageing, although these differences were not significant. Similarly, there was no effect of Boa treatment on WBC.

Suspension drip measures the freely-available water; that is, the fluid that is loosely contained and not bound by the myofibrillar proteins and is therefore representative of purge that would occur during vacuum packed primal storage. Only the cube roll samples were assessed for suspension drip and these showed typical decreases in percentage of drip after longer storage periods. By day 3 the majority of freely-available water had already been lost and by day 14 the percentage of drip loss by this method had significantly decreased compared to the earlier ageing timepoints ($p \leq 0.001$). There was no significant effect of Boa treatment on suspension drip although the Boa treated samples tended to have higher drip losses after each ageing timepoint compared to the control samples.

Drip losses during retail display were also not significantly affected by Boa treatment. While boa-treated cube roll samples tended to lose more fluid during retail display compared to the controls, in the other cuts (the tritip and the abductor and semimembranosus from the topside) this trend was reversed and the control samples lost more drip. Overall, losses of around 1% were found in both Boa and control samples and these are typical of fluid losses typically found during retail display.

ii) Shear force

As expected, tenderness improved with increased periods of chilled storage with significant improvements in tenderness occurring after 3 and 7 days of ageing ($p \leq 0.001$). Irrespective of treatment, the tritip was significantly tougher than the other cuts ($p \leq 0.001$). There was no significant effect of Boa treatment on tenderness but samples that had been treated with the Boa tended to be more tender than the control samples, during the first 7 days of ageing although generally this effect was no longer evident after 14 days of ageing (See Figure 8).

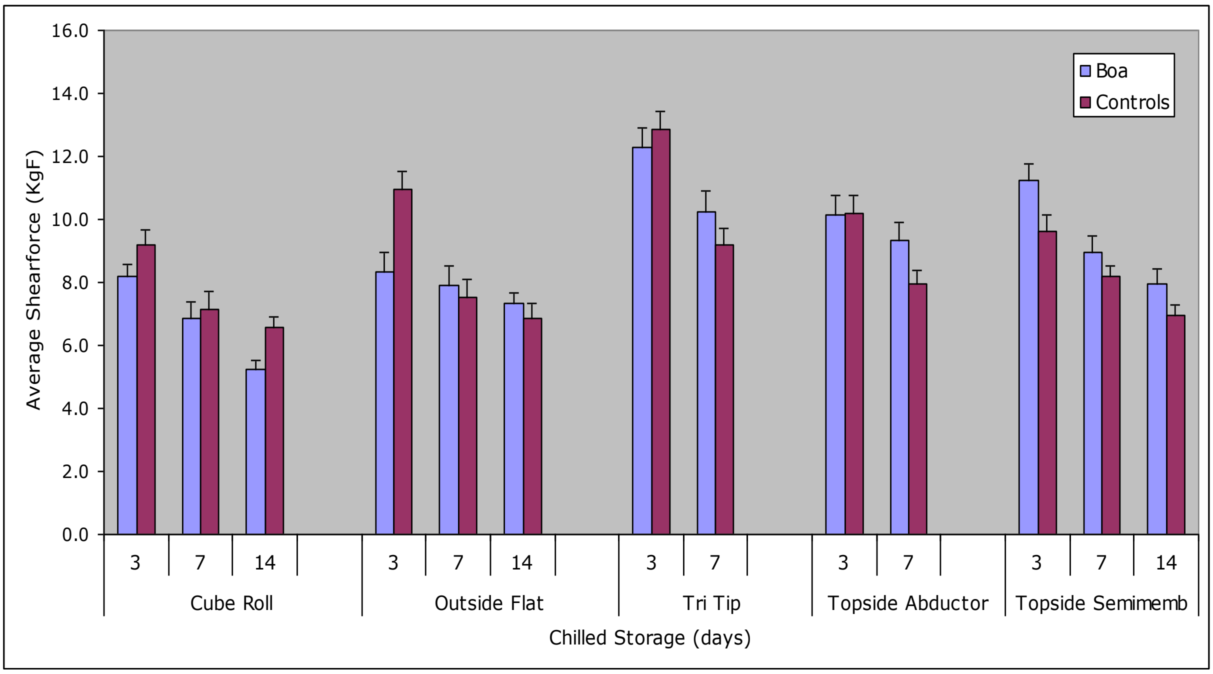
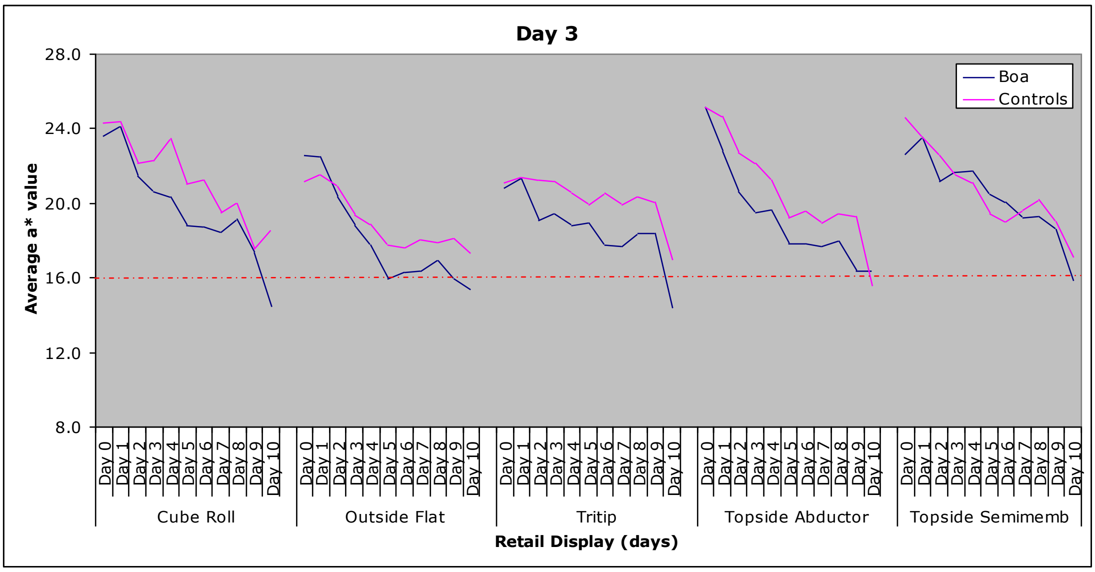


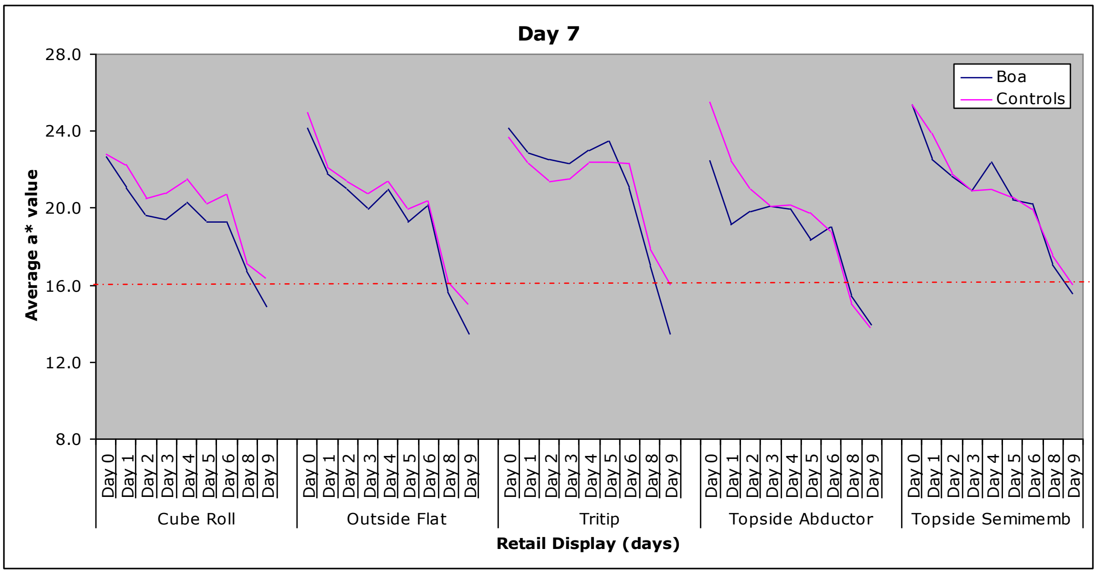
Figure 8. Tenderness for each muscle after storage.

iii) Colour stability

The colour stability after different periods of ageing is shown in Figure 8 below: The a* values only have been shown as these are a measure of redness and tend to correlate most closely with consumer responses of colour acceptability during retail display.

After each ageing period of 3, 7 and 14 days, the control samples had significantly higher a* values ($p \leq 0.001$). However, with increasing days on retail display the differences in a* values between the control and Boa treated samples became less marked (See Figure 9).





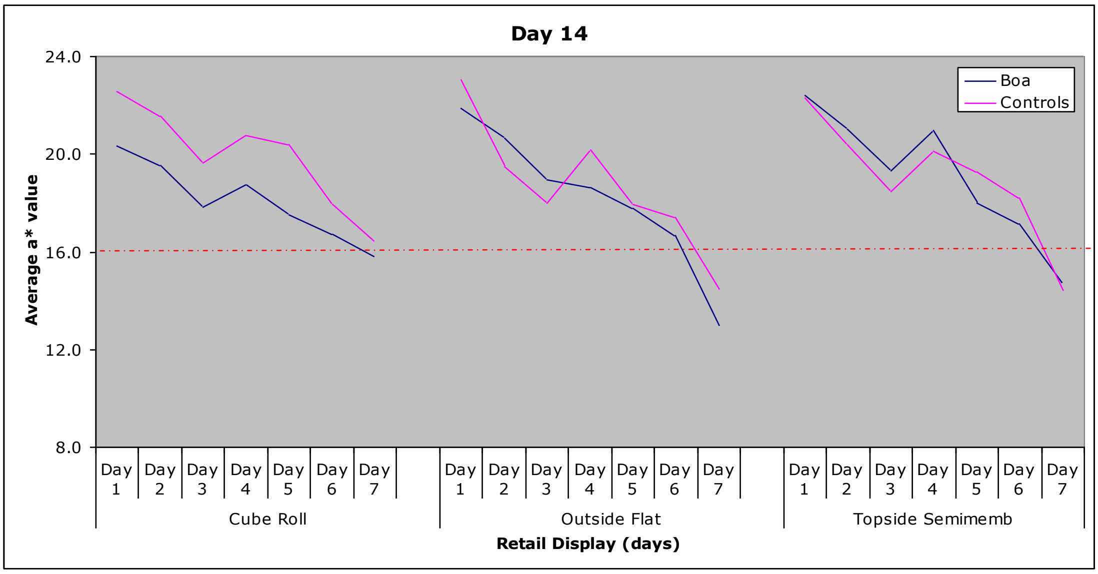


Figure 9. Colour a* values after 3, 7 and 14 days chilled storage.

4.3.2 Australian pilot processing trials

The meat quality traits of the Australian component of the meat stretching evaluation “Utilising the Boa stretching technology to improve the quality of hot boned striploins” are summarised in Table 5.

Table 5: Mean meat quality traits, variance, and range.

Trait	Day p.m.	n	Mean	SD	Min	Max
Shear f. (N)	1	120	56.0	13.4	36.4	119.0
	7	120	50.8	12.8	29.0	118.7
	21	120	42.9	7.3	29.4	68.5
Cook loss (%)	1	120	19.6	2.8	13.4	26.9
	7	119	18.0	1.8	11.9	22.0
	21	120	17.5	1.9	12.5	21.5
Sarc. l. (µm)	1	120	1.97	0.19	1.60	2.41
Thaw loss (%)	1	120	6.0	2.3	1.4	11.3
pHu	1	120	5.58	0.08	5.45	5.88
T@pH6	-	101	24.5	11.4	4.3	43.0

Results on the individual traits are discussed in the following text:

i) Temperature and pH

As mentioned in the introduction, an anticipated effect of the Boa treatment was that rapid chilling could prevent denaturation of µ-calpain during the early post mortem period, thereby possibly maximizing the tenderising effect of ageing. To be able to evaluate the effects of the Boa treatment independent of chilling effects, half of the Boa samples were wrapped in bubble wrap, mimicking the insulating effect of fat cover in intact carcases. It was evident from the results that the bubble wrap was not sufficient to insulate the Boa samples compared with the corresponding samples in the intact carcass sides (Table 6). In the intact carcasses, the temperature of the loins was about 30°C when the pH reached 6, whereas it was about 20°C for the wrapped loins. The rapidly chilled Boa samples reached pH 6 at a temperature of about 10°C, which in unrestrained muscles would likely result in cold-shortening. Ultimate pH was not affected by the treatments.

Table 6: Predicted sarcomere length (µm), thaw loss (%), ultimate pH, and temperature at pH 6 for the different treatments.

Trait	AT	TS	SS	BC	BI	Max. s.e.
Sarc. L.	1.73^{d}	2.03^{b}	2.19^{a}	1.99^{b}	1.91^{c}	0.03
Thaw loss	7.1^{a}	5.0^{b}	4.4^{b}	6.2^{b}	7.1^{a}	0.5
pHu	5.60	5.59	5.60	5.56	5.56	0.02
T@pH6	30.4^{a}	30.6^{a}	32.0^{a}	20.4^{b}	10.5^{c}	1.7

ii) Shear force and cooking loss

Table 7 showed that the treatment x ageing interaction was significant (P<0.05) for both shear force and cooking loss. Predicted means in table 8 showed that loins from achilles tendon hung carcasses had the highest shear force throughout the ageing period. Loins from the TS, SS, and BC treatments displayed a similar tenderness throughout the ageing period. Not only were they significantly more tender than AT treated samples, but the variance in tenderness was also 2-3 fold lower. BI treated samples displayed an intermediate ageing response. At one day post mortem, these samples were significantly tougher than TS samples, but this difference diminished during further ageing.

Table 7. F-ratios for the effect of treatment, ageing, and treatment x ageing on shear force and cooking loss.

Independent variables	Shear force			Cooking loss
	NDF, DDF	F-ratio	NDF, DDF	Cooking loss
Treatment	4, 226	19.8***	4, 225	2.9*
Ageing	2, 226	51.8***	2, 225	29.9***
Treatment x Ageing	8, 226	2.6*	8, 358	0.7n.s.

Table 8. Predicted shear force (N) and cooking loss (%) for the interaction between treatment and ageing.

Trait	Day p.m.	AT	TS	SS	BC	BI	Max. s.e.
Shear force	1	71.5^{a}	49.1^{c}	50.5^{bc}	51.9^{bc}	56.1^{b}	2.5
	7	63.1^{a}	49.6^{b}	45.9^{b}	49.0^{b}	46.4^{b}	2.5
	21	48.9^{a}	40.5^{b}	41.8^{b}	40.4^{b}	41.5^{b}	2.5
Cook loss	1	21.0^{a}	19.5^{b}	19.9^{ab}	19.0^{b}	18.8^{b}	0.5
	7	18.9	17.7	17.9	17.6	18.0	0.5
	21	18.2	17.6	17.0	17.2	17.5	0.5

iii) Sarcomere length and muscle length

The different stretching treatments resulted in a significant increase in sarcomere length as compared to the AT treated samples (Table 6). Among these treatments, superstretching resulted in the largest sarcomere lengths. The BI treatment resulted in shorter sarcomere lengths than the BC treatment. This may indicate that the amount of restraint on the BI samples was insufficient to completely prevent shortening under cold-shortening conditions. However, the restraint was sufficient to prevent real cold-shortening.

The effect of the Boa treatment on muscle length was quite variable with a mean increase of 14.5% with a minimum of 2% and a maximum of 43.5%. The relevance of this variable may be questionable, since the contraction status of the excised muscle may vary before the treatment, and some shortening may occur during chilling. This was reflected in a relatively weak correlation between increase in muscle length and sarcomere length (r = 0.37). Alternatively, the large variation in the effect of the Boa treatment on muscle length may simply reflect the variation in sample size, whereupon thicker muscle samples were effectively stretched more than thinner samples. If this was the case, it suggests that the operation of the Boa technology needs to be modified to achieve a constant level of stretch regardless of the thickness of the pre-rigor sample.

iv) Thaw loss

These measurements were originally not part of the project plan. However, during the course of the experiment it was noted that the casings of the BI treated samples appeared to contain relatively large amounts of purge. Therefore to test whether the treatments affected water-holding capacity this measurement was performed. The results showed that waterholding capacity was indeed affected by the treatments (Table 6). Both TS and SS samples displayed decreased thaw loss as compared to the other treatments.

v) Colour and colour stability

Table 9 showed the significance of treatment effects and relevant covariates on colour parameters. Although the treatments had a significant effect on colour parameters, the absolute differences were marginal. In general, the SS samples displayed the highest L*- and a*-values, indicating a brighter and redder colour (data not shown). Samples aged for 21 days showed the largest decline in a*-value during the storage period. However, as illustrated in figure 10, the different treatments did not affect colour stability to a noticeable effect.

Table 9: F-ratios for the significant effects of treatment, ageing, display time, position within the muscle, ultimate pH and temperature at pH6, and their interactions on L*-, a*, and b* values.

Independent variables		L*-value	a*-value	b*-value
	NDF, DDF	F-ratio	F-ratio	F-ratio
Treat	4, 1726	13.3***	10.6***	53.4***
Ageing	2, 1726	270.3***		78.5***
Display	5, 1726	12.2***	810.6***	169.8***
Treat x Ageing	8, 1726	2.5**	6.7***	5.3***
Treat x Display	20, 1715			2.4***
Ageing x Display	10, 1726	2.2*		82.9***
Position	2, 1726	12.5***	.	20.0***
Ultimate pH	1, 1726	22.7***	8.9**	12.0***
Temp. at pH6	1, 1726	7.1**		5.1*

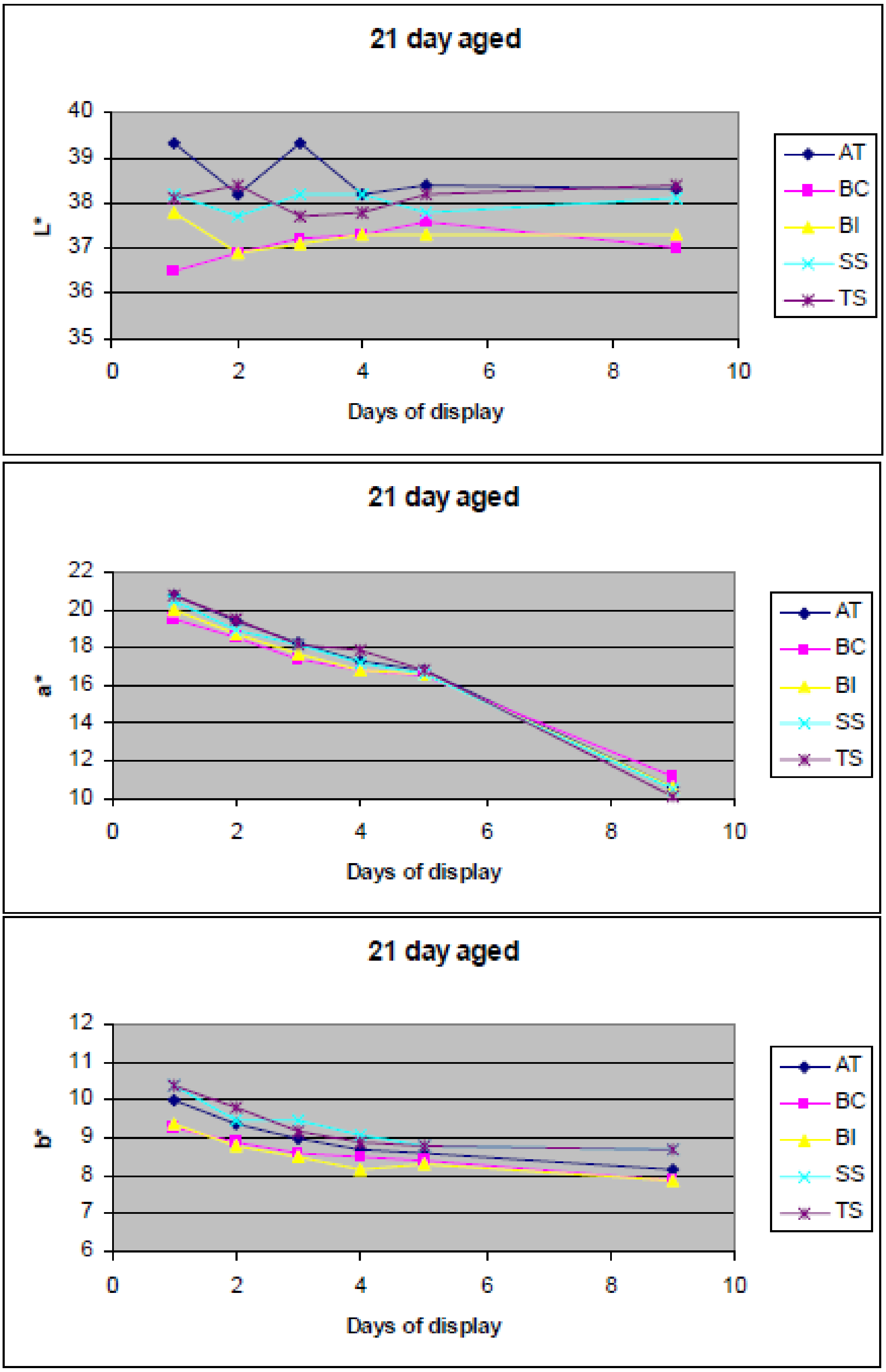


Figure 10: L*-, a*, and b*-values during display for 9 days at 3°C. Treatments: AT = Achilles Tendon, BC = Boa Chill, BI = Boa Ice, SS = Superstretch, TS = Tenderstretch.

4.4 Consumer evaluation (Milestone 4)

The average MSA consumer scores on striploins that have been subjected to various forms of carcass restraint or pre-rigor stretching and reforming are shown in Table 10.

Table 10: MSA consumer evaluations.

TRAIT		AT		SS		TS	
	Days	Boa	Control (AT)	Boa	Control (SS)	Boa	Control (TS)
Tender	16	51	36	44	45	41	42
	28	57	48	53	54	52	54
Juicy	16	48	41	43	46	42	39
	28	50	47	50	53	43	47
Flavour	16	54	45	48	51	48	51
	28	52	51	55	57	52	55
Overall liking	16	53	40	46	48	45	46
	28	54	51	53	57	50	53
CMQ4	16	52	40	45	48	44	45
	28	54	50	53	55	50	53
Satisfaction	16	3.0	2.7	2.8	2.9	2.8	2.8
	28	3.1	3.0	3.1	3.2	3.0	3.1

Summarising these data, the Boa, Super Stretch and Tender Stretch treatments result in broadly equivalent scores in samples aged for either 16 and 28 days ageing and all these scores are all significantly greater than those from the Achilles suspended treatment. The illustration (Figure 11) below shows a diagrammatic comparison of the statistical model (note that there is standard error of about 1 unit for each estimate on this scale):

Figure 11: Diagrammatic representation of CMQ4 data.

In each case, the animal effect was highly significant; the ageing period was significant, but the hang (suspension) difference was only significant for BO vs AT; the interaction (hang × days aged) was not significant in all cases. In each case the ageing effect, i.e. the difference between the result for 28-day and 16-day ageing, for whichever hanging method, was approximately +7 CMQ4 points.

These data after 16 and 28 days ageing have been plotted in Figures 12 and 13 respectively.

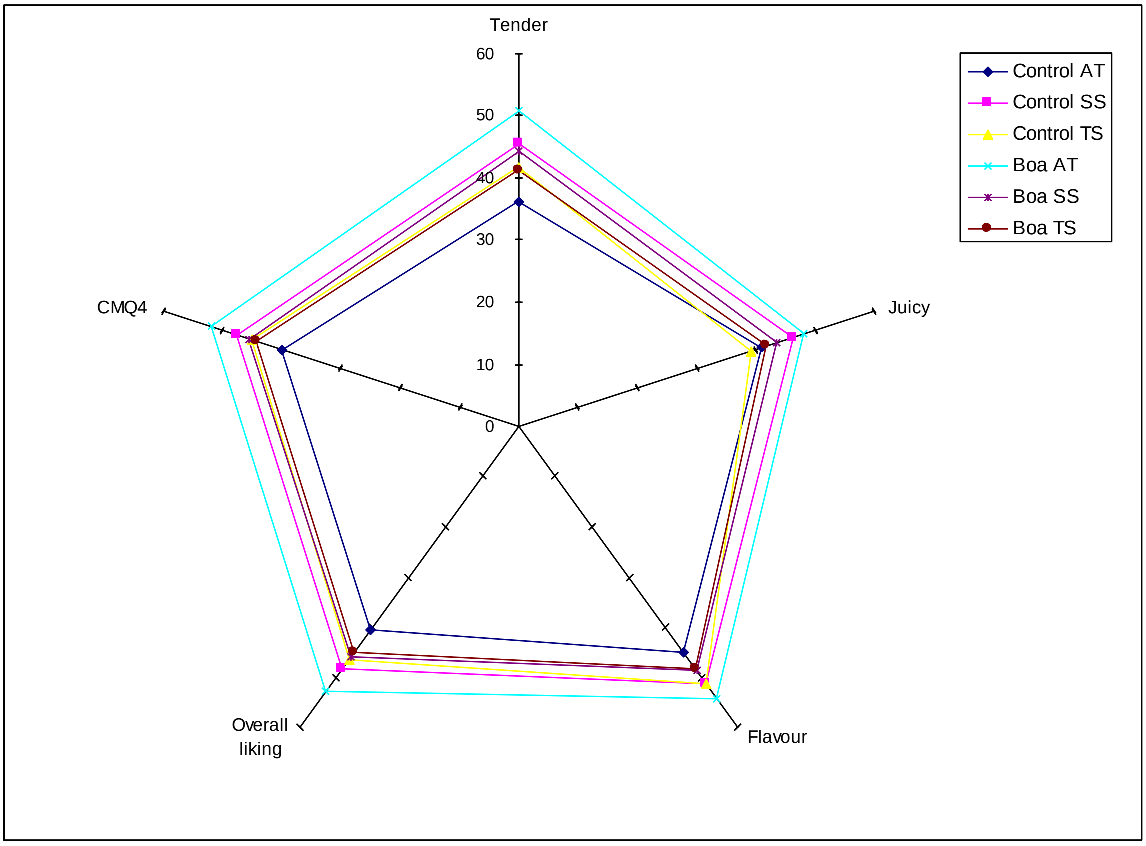


Figure 12: MSA Consumer data from samples following 16 days ageing.

After 16 days ageing, the SS, TS and equivalent BO samples show similar levels of scoring whereas the AT vs BO samples are significantly different, particularly so for the attribute of tenderness; consumers found the BO treated samples more tender than the AT treated samples. These differences are no longer apparent after 28 days of ageing (Figure 14).

Figures 14 and 15 show the satisfaction rating as evaluated by the MSA consumers. Clearly, after 16 days of ageing, consumers found samples from the BO treatments more satisfactory than the contralateral AT treated samples while comparisons between SS and the BO showed that SS was viewed as more satisfactory while the TS and BO treatments were generally equivalent.

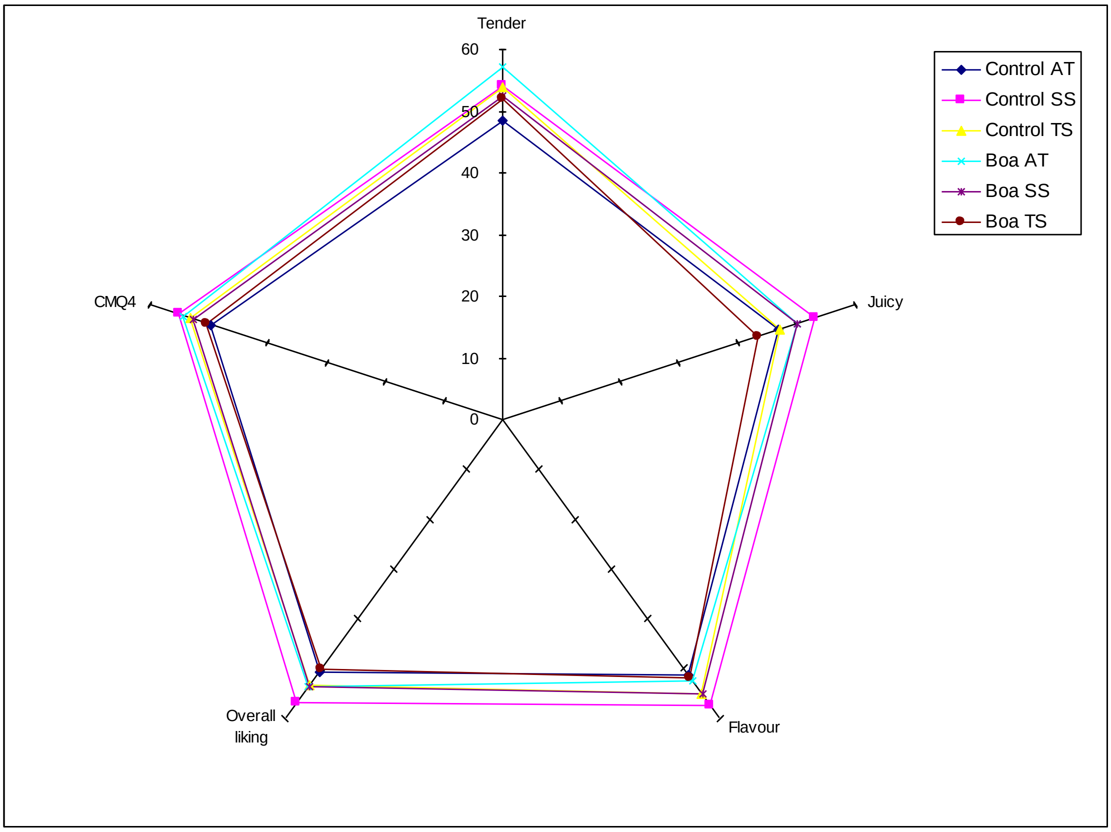


Figure 13. MSA consumer data from samples following 28 days ageing.

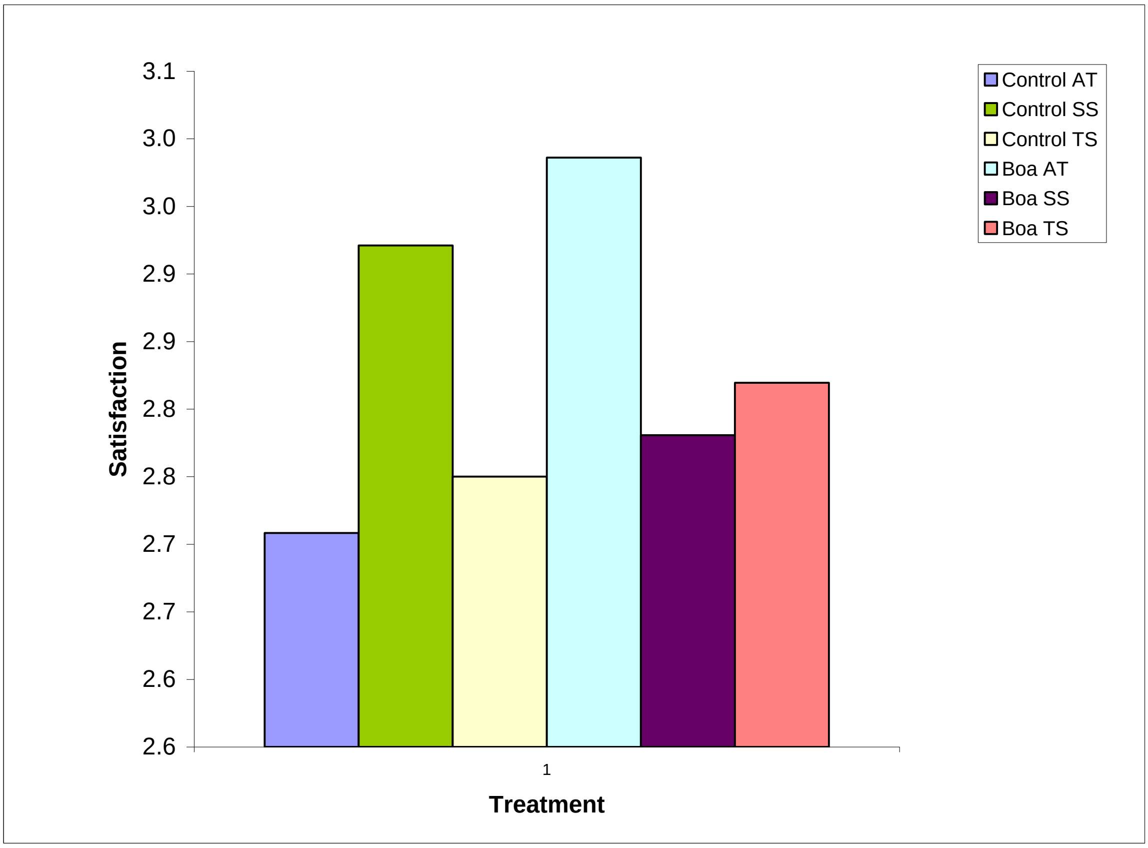


Figure 14: MSA Consumer satisfaction rating after 16 days ageing.

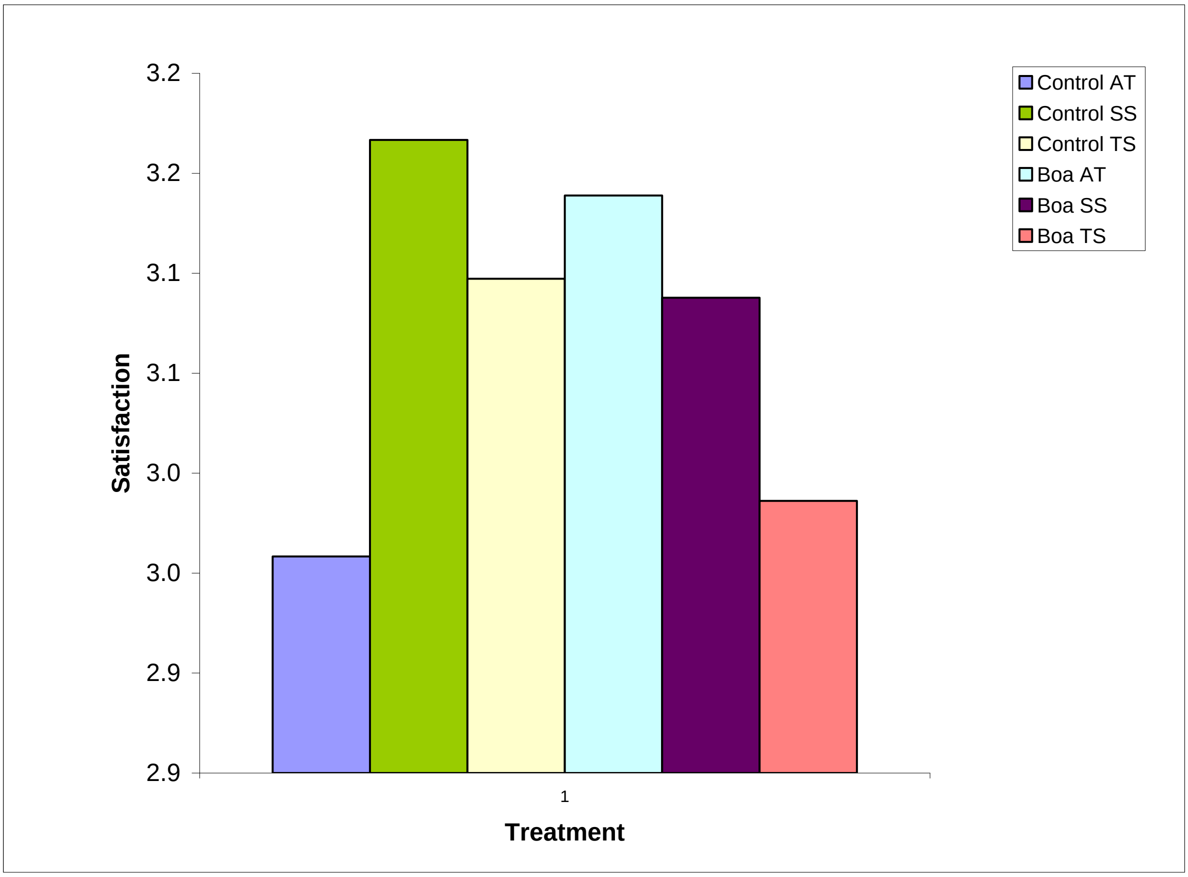


Figure 15. MSA Consumer satisfaction rating after 28 days ageing.

4.5 Commercialisation guidelines and initial considerations (Milestone 5)

A review of current providers and assessment of their capability was undertaken, in order to develop a draft adoption and commercialisation plan. A tender process to the entire market was undertaken. The following were the key considerations:

- Exclusivity (for set reasonable period)
- In-house (local?) engineering, design and development capabilities & capacities in food industry(s)
- Value chain partners & track record for adoption and commercialisation of red meat technologies and products
- Opportunity to access and service of Australian red meat industry
- Vision including fully automated meat plant
- (Based on a tender document disseminated) Have indicated interest in trialling the technology

5. Discussion

5.1 Meat quality (New Zealand) trials

These results show clearly that the Boa successfully reformed several key prime beef cuts to generate a highly acceptable portion control product. Unfortunately, overall the level of stretch of each of the cuts was minimal and although several of the cube rolls were stretched to approximately 20% or greater, the majority of the cuts were stretched by only 2 to 3%. This is clearly reflected in the meat quality data; although the trend was for the Boa treated product to have lower shear forces than the untreated controls these differences were not significant. This is in contrast to previous trials using various stretching techniques that have shown clearly that if the level of stretch exceeds 20% then the shear force is significantly lower compared to unstretched controls during the first 7 days of ageing.

Similarly, the other meat quality attributes did not differ between the Boa treated and the control cuts; the fluid losses as measured by WBC, suspension drip loss, drip loss during retail display and cook loss did not differ. As with shear force, past work on pre-rigor stretching of beef has shown some significant effects on purge reduction.

Somewhat surprisingly, the colour of the samples was negatively affected by the Boa treatment. The redness (a* values) were significantly lower at all times for all cuts during retail display compared to the untreated cuts. Past trials using other techniques to stretch and reform the cuts have typically resulted in slightly improved colour and, although these differences have not always been statistically significant, the trend has always been evident. However, as discussed earlier, the level of stretch obtained in the majority of cuts in this trial was generally fairly minimal and the positive effects of stretching on colour have previously only become evident in samples that have been stretched to a high level (typically greater than 25%). While the mechanism for this colour improvement is not apparent, clearly this trial highlights the importance of achieving a high degree of stretch for this effect to be realised.

The response from the participating plant towards the Boa and the resultant cut shapes was extremely positive; The Boa fitted comfortably in one area of what is a small boning room and product flow to the Boa was efficient. The shape of the topside and tritip was of particular interest and the opportunity to shape and reform these lower value cuts thereby increasing their value, was of interest to this plant. The lack of any marked improvement in meat quality was deemed of lesser significance than the successful shaping of the cuts.

5.2 Australian pilot processing trials

The stretching treatments resulted in a significant increase in sarcomere length over the AT treatment, with a concomitant decline in shear force (See supporting documents for the full report in the Appendix, refer to Section 7.3). In addition, the stretching treatments resulted in a 2-3 fold decrease in variance of shear force as compared to the AT treatment. Thaw loss was decreased by the TS and SS stretching treatments, but not by the Boa treatments. Colour parameters (L*, a*, and b*) were significantly affected by the effects of treatment, ageing, display time (1-9 days), and their interactions. However, no significant effects on colour stability during display were noted.

The results of this experiment have shown that the Boa technology can improve the tenderness of hot-boned striploins to a similar level as striploins from tender-stretched or super-stretched carcasses. No beneficial or adverse effects were noted for colour stability. A possible negative effect of the Boa technology is a reduction in water-holding capacity as compared to other stretching treatments.

The results from this experiment confirm the notion that stretching of muscle to a sarcomere length of about 2.0µm or greater results in a significant improvement in tenderness and a reduction in the variation in tenderness. Three of the treatments (SS, TS, BC) achieved this level of stretching, resulting in similar levels of tenderness. The hypothesis that stretching combined with accelerated chilling might result in an increase in tenderisation during ageing was not reflected in the shear force values after 21 days of ageing. It must be noted, however, that the pH and temperature decline in the intact carcasses was well within the MSA window. A reduction in tenderisation as a result of adverse pH and temperature conditions (heat-shortening) would not have occurred in these carcasses.

The results with regard to water-holding capacity are somewhat puzzling. In general, an increase in sarcomere length results in increased water-holding capacity. The results for the AT, TS, SS, and BI treatments appear to confirm this fact. However, BC treatment resulted in an increase in thaw loss as compared to the TS treatment, despite the fact the sarcomere lengths were similar. Moreover, the faster chilling treatment would have prevented protein denaturation, and thus improved waterholding capacity, in the BC samples as compared to the TS samples. Yet, the result was the opposite. The reason for this is unclear. The impression that BI treatment resulted in a decrease in waterholding capacity as compared to BC treatment was not evident from the thaw loss measurement. However, if the impression that BI treatment resulted in larger amounts of purge in the casings, than the combined fluid loss would be greatest from BI treated samples.

On the basis of results from previous experience, an improvement in colour stability as a result of the Boa treatment was anticipated (N. Simmons; pers. comm.). The results from the present experiment do not confirm this.

With regard to the Boa technology it has been shown that it can be used to improve the tenderness of hot-boned loins to a similar level as other stretching technologies on cold-boned carcasses. In addition, it has been shown that manipulation of the chilling regime was far more flexible than the chilling regime of intact carcases. Future research may be aimed at increasing the level of stretch achieved with this technology and determining the optimal chilling conditions. In addition, this technology might be tested to improve the tenderness of muscles that are not affected by stretching techniques on intact carcasses.

5.3 Consumer evaluation

Generally, the overall satisfaction for all samples increased with the additional ageing period (16 vs 28 days of ageing) although the trends between the various treatments continued to follow the same pattern.

Taken collectively, these data show that treatment with the Boa results in an improvement in meat quality, as evaluated by consumers, and these improvements are in keeping with those offered by other techniques that result in stretching of the striploin while it is maintained on the carcass (TS & SS). All three treatments (BO, TS, SS) result in meat higher quality scores when compared to the traditional AT treatment (Achilles suspension) irrespective of the amount of sample ageing prior to consumer evaluation.

6. Conclusion and recommendations

6.1 Conclusions

6.1.1 Meat quality trials (New Zealand pilot trials)

These results show clearly that the Boa successfully reformed several key prime beef cuts to generate a highly acceptable portion control product. Unfortunately, overall the level of stretch of each of the cuts was minimal and although several of the cube rolls were stretched to approximately 20% or greater, the majority of the cuts were stretched by only 2 to 3%. This is clearly reflected in the meat quality data; although the trend was for the Boa treated product to have lower shear forces than the untreated controls these differences were not significant. This is in contrast to previous trials using various stretching techniques that have shown clearly that if the level of stretch exceeds 20% then the shear force is significantly lower compared to unstretched controls during the first seven days of ageing.

Similarly, the other meat quality attributes did not differ between the Boa treated and the control cuts; the fluid losses as measured by WBC, suspension drip loss, drip loss during retail display and cook loss did not differ. As with shear force, past work on pre-rigor stretching of beef has shown some significant effects on purge reduction.

The response from the participating plant towards the Boa and the resultant cut shapes was extremely positive; The Boa fitted comfortably in one area of what is a small boning room and product flow to the Boa was efficient. The shape of the topside and tritip was of particular interest and the opportunity to shape and reform these lower value cuts thereby increasing their value, was of interest to this plant. The lack of any marked improvement in meat quality was deemed of lesser significance than the successful shaping of the cuts.

6.1.2 Australian pilot processing trials

The stretching treatments resulted in a significant increase in sarcomere length over the AT treatment, with a concomitant decline in shear force. In addition, the stretching treatments resulted in a 2-3 fold decrease in variance of shear force as compared to the AT treatment. Thaw loss was decreased by the TS and SS stretching treatments, but not by the Boa treatments. Colour parameters (L*, a*, and b*) were significantly affected by the effects of treatment, ageing, display time (1-9 days), and their interactions. However, no significant effects on colour stability during display were noted.

The results of this experiment have shown that the Boa technology can improve the tenderness of hot-boned striploins to a similar level as striploins from tender-stretched or super-stretched carcasses. No beneficial or adverse effects were noted for colour stability. A possible negative effect of the Boa technology is a reduction in water-holding capacity as compared to other stretching treatments.

6.1.3 Consumer evaluation

Generally, the overall satisfaction for all samples increased with the additional ageing period (16 vs 28 days of ageing) although the trends between the various treatments continued to follow the same pattern.

6.2 Future research and recommendations

It is recommended further R&D is required

- Design and next phase of prototype.
- Commerciaisation pathways further refined and supplier agreement in place.
- Product quality validation ongoing - The Boa technology has been shown to improve the tenderness of hot-boned striploins to a similar level as striploins from tenderstretched or superstretched carcasses. No beneficial or adverse effects were noted for colour and colour stability. A possible negative effect is a reduction in water-holding capacity. The reason for this is unclear.

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8. Acknowledgements

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication. MLA partnered with Meat and Wool New Zealand and wishes to acknowledge their contribution to the project.

9. Appendix

9.1 Operating guidelines

Carne Technologies

Meat Stretcher (Boa) Operators Manual

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Contents

Introduction

As part of the MQST programme, a prototype meat stretching device (patent pending) commonly referred to as the 'Boa' has been designed and built. There are two units currently being trialed; one in New Zealand and one in Australia.

Meat is inserted into a rubber sleeve and pressure is applied to squeeze the meat out (much like a Boa constrictor, hence the nickname). Pressure is applied in two stages; firstly via four inflatable bags located internally (behind the rubber sleeve) and secondly via pressure applied to the rubber sleeve itself. As meat is squeezed it is discharged into packaging that has been located directly above the opening of the rubber sleeve.

Once in the packaging, the meat cannot return to its rest length or shape and is therefore maintained in this manner during rigor and subsequent chilled storage. Once the meat is unwrapped it maintains its shape during further cutting, sample handling and cooking.

Successful operation of the Boa is reliant on the following factors:

- Pressures applied to both the inflatable bags and rubber must be set correctly; firstly for the system to operate and secondly to achieve the target level of stretch. This may need to be adjusted for varying meat/muscle sizes.
- Packaging size (diameter) is critical; too small and the meat cannot be expelled from the Boa into the package, too large and the stretch/shape of the meat sample will not be maintained.
- Meat that is put through the Boa while it is still in the pre-rigor state (hot-boned) is readily stretched and reformed (depending upon the cut).

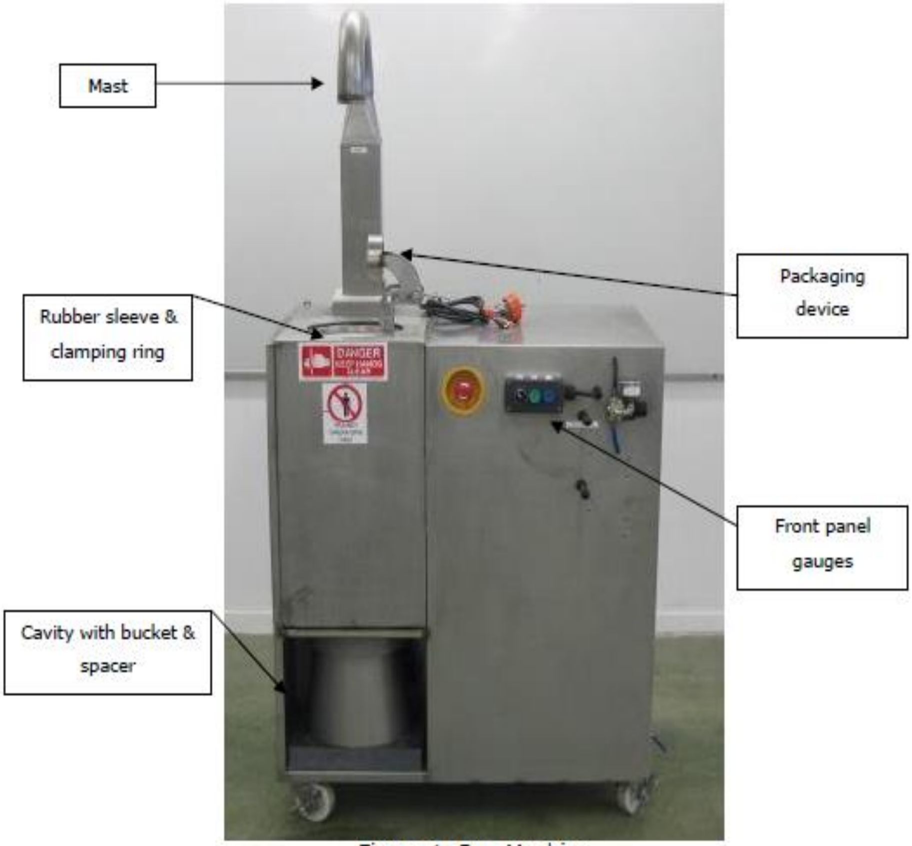

Figure 1. Boa Machine

Figure 2a. Rubber sleeve 'closed'

Figure 2b. Rubber sleeve expanded to allow insertion of meat sample

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Standard Operating Procedures

The following operating procedures relate directly to the prototype machine in use in New Zealand. This machine has been identified and labelled as 'Prototype Boa NZ1'.

It is recommended that operators familiarise themselves with the settings required for different muscle sizes to be put through the Boa, as well as the general functionality of the Boa.

Initially the optimal pressures will need to be set and adjusted to accommodate meat pieces of different sizes and shape: Gauge B is adjusted to apply the optimal pressure of squeeze from the internal inflatable bags. Gauge A can then be adjusted as required for fine-tuning of pressure required to expel meat from the rubber sleeve. In some instances, extra pressure can be applied to the rubber sleeve by adjustment of Gauge E; however if this pressure adjustment is required it may be an indication of a fault within the Boa (likely to be due to leaks within the air system). (Please see Figures 3 and 9 for details of the various gauges).

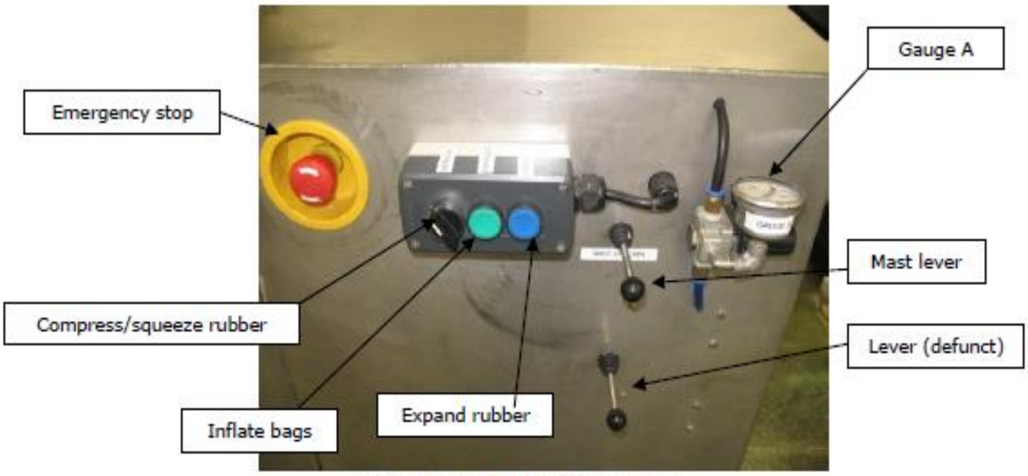

Figure 3. Front panel gauges

General Operation of Boa

1. Ensure the unit is clean and ready for use;
    a. Lubricate the rubber with a food grade oil to ensure the meat slides against the rubber sleeve easily.

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   b. Remove back panel to check gauges for correct settings (see section titled 'adjusting and selecting air pressures'.
   c. Ensure vacuum pump is plugged in (internal power).
   d. Leave panel off while operating as heat builds up due to vacuum pump.
   e. Check that the spacer and bucket are in place in the cavity underneath the rubber housing.
   f. Lock the transportation wheels to prevent the Boa from shifting during operation.
2. Plug in machine (power source = standard single phase 230-240 Volt) and turn on power.
3. Connect air supply to the unit via the arrow quick-connect pneumatic air fitting valve at rear of machine;
   a. Minimum air pressure should be 5 Bar (70 PSI), ideal is 5 to 6 Bar (70 – 90 PSI) and maximum is 10 Bar (145 PSI).
   b. Diameter of supply air hose should be at least 10mm.
4. Ensure machine is in operational mode;
   a. Red emergency stop button in 'out' position.
   b. Raise the mast to full height to be out of operators' way.
   c. Connect the TV monitor (for viewing inflation of bags).
5. Attach the packaging device with the appropriate ring and bag size. The ring and bag size can be selected and replaced before each insertion of meat into the Boa.
6. Press the blue button to expand the rubber sleeve (Figure 2a).
7. As soon as the rubber sleeve is expanded sufficiently insert the meat and quickly lower the packaging device into the mouth of the rubber sleeve and lock it into place.
   a. Note: Once the rubber sleeve has expanded to its maximum point it will close up onto the meat completing the cycle. Pushing the red stop button will override the cycle and make the rubber sleeve close up.
8. Release the red stop button (if used) and press and hold the green button to inflate the internal inflatable bags.
   a. If bags are over-inflated, release the green button and the bags will deflate. Press the green button again to re-inflate.
   b. Use of the TV monitor will allow user to view inflation of the bags.
   c. Regulate the inflation by alternately pressing and releasing the green button.

9. While still depressing the green button turn the switch to compress/squeeze the rubber to squeeze the meat out into the packaging.
    a. If required, increase the pressure of the rubber sleeve using Gauge A (clockwise).
10. Once the meat is in the packaging sleeve release the green button and switch to off position. If required, open the rubber sleeve by pushing the blue button.
11. Simultaneously remove meat from the rubber and lift the packaging device up locking into starting position.
12. Remove meat from the packaging device, ensure meat is fully in packaging and clip ends of bag to seal.
13. After use of the Boa shut down and return to safety position (bucket covering rubber sleeve, mast down). (Figure 5).

Fitting of Parts

Bucket & Spacer

The space underneath the rubber sleeve should be closed in to stop the rubber from bulging out from underneath while under pressure. As a temporary solution, a stainless bucket and plastic spacer are put in this space during operation of the unit (Figure 4).

(i) Place the bucket upside down into the space.

(ii) Slide the spacer completely in under the bucket so that the bucket sits firmly on it and the spacer is hard up against the back wall.

(iii) Check by looking down through the rubber that the bucket is in place and no gaps are visible.

Figure 4. Bucket & spacer in cavity

Safety Position (Boa not in use)

After use, the bucket and spacer, along with the mast are positioned in the recommended manner to stop any objects being placed into the rubber sleeve (Figure 5) thereby protecting it from damage.

(i) Place the bucket, upside down over the opening of the rubber.

(ii) Place the spacer on top of the bucket.

(iii) Lower the mast using the lever so that it sits tightly onto the spacer.

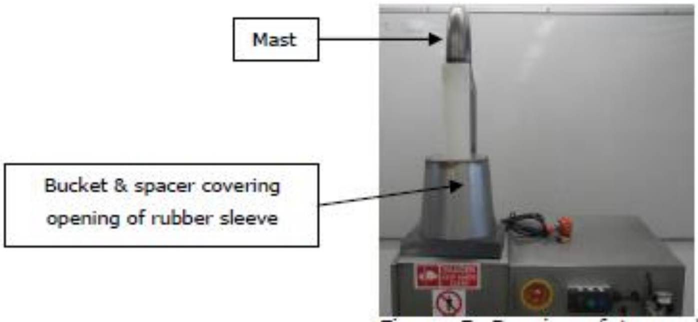

Figure 5. Boa in safety mode

Packaging Device

Loading of packaging material

1. Ensure the packaging device is locked into position; unit is upright and sitting in the back locking grooves (Figure 6a).
2. Push the handle fully down to lock into place.
3. Packaging film is inserted through the ring from the rear towards the opening of the rubber.
4. The film is opened out and pushed over ring of packaging device.

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Figures 6a, b & c. Packaging device locked in upright position, unlocked position and locked in rubber sleeve ready to receive meat sample

Loading meat into the packaging device

1. Once packaging is in place lift the handle to unlock the apparatus.
2. Load meat into Boa.
3. Slide the packaging ring along the arms of the device placing over the mouth of the rubber sleeve opening, which is fully expanded, and lock into position (Figures 6b and c).
4. Expel meat into the packaging.

Changing the ring size

1. Remove the handle and undo the two sets of bolts on one side of the apparatus.
2. Take out the two shafts.
3. Packaging ring can now be removed and replaced with appropriate ring size.
4. Replace packaging device and tighten bolts (finger tight).

Figure 7. Packaging device disassembled

Replacing Internal Inflatable Bags

1. Release the rubber sleeve from the clamping device/plate (see section on 'Changing the Rubber') but do not fully remove. The rubber sleeve can now be pushed aside for access to the inflatable bags.
2. Disconnect the bag from the airline: release by pushing the blue ring up on the fitting to release the hose.
3. Replace with new inflatable bag.
4. Reconnect airline hose to the inflatable bag: the fitting snaps into place.
5. Position the inflatable bag and adjust the bands holding it in place to ensure no constriction of airlines. The bags sit against a curved bracket and are held in place with bands. Bags should be placed as high as possible for maximum squeeze to be achieved.
6. Adjust the camera if it has been knocked out of alignment.
7. Reinstall the rubber.

Changing the Rubber

1. Remove the bucket & spacer from the cavity.
2. Remove the air supply from the machine.
3. Inside the Boa, unplug the 'clamp hose' from the clamp and replace with the 'release hose'.
4. Reconnect air supply – the rubber sleeve will be released at the top and bottom.
5. Very quickly grasp the rubber sleeve edge at the top and pull inwards. Note: This action is to be performed quickly to ensure fingers don't become trapped between the rubber sleeve and the clamping plate of the machine.

Figure 8. Rubber and clamp plate

6. Continue to pull the rubber sleeve into the centre until all edges are released from the clamping faces.
7. Extract rubber sleeve from the top by pulling up and out. May be required to fold the bottom edging of the sleeve to release.
8. Insert new rubber sleeve. Ensure it is placed right way up (the inner surface of the rubber sleeve is smooth at the top end and the bottom end has a ridge).
9. Adjust inflatable bags and ensure bands holding bags in place are not constricting any airlines.
10. Adjust camera position (may have been knocked out of alignment during removal of rubber sleeve).
11. Adjust the rubber sleeve to a central position making sure the edges are aligned with the clamping plate.
12. While holding the rubber sleeve in a central position, remove air supply. Spring tension will close the clamping system. Warning: Do not place fingers near the clamping plate or between the plate and rubber due to danger of crushing.
13. Manually adjust the rubber sleeve around the clamping plate to ensure all edges are fully under the plate. The rubber sleeve can be manipulated by pushing back under the plate, and if required a blunt tool can be used to assist in pushing the ridges of the rubber sleeve under the clamping device.
14. Change the release hose back to the clamp hose.
15. Reconnect air supply – the rubber will pull in further and clamp tight. Check that it is all central and there are no air leaks (will hear a hissing sound if leaking). Repeat steps above if an air leak is present.

Adjusting & Setting Air Pressures

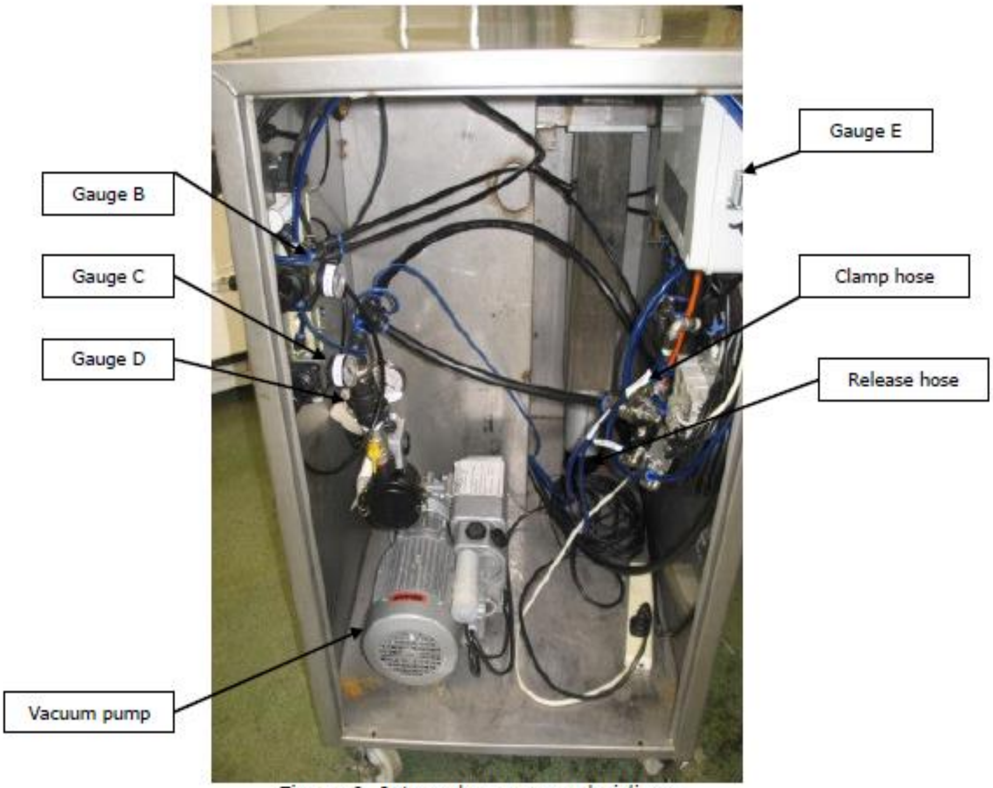

Figure 9. Internal gauges and airlines

Gauge A – Rubber Sleeve Pressure Regulator

Gauge A is used to regulate the air pressure applied to the rubber sleeve and discharge meat. Note: Pressure is **not to exceed 1 Bar** (100kPa).

Initial settings should be set at the minimum required to expel meat and increased as required; this is dependant on the meat size, bag size and if the meat is in the pre or post rigor state. For example; a larger, firmer portion of meat may require increased pressure to expel it from the rubber sleeve.

During normal operation, if more pressure is required to expel the meat, then adjust the pressure regulator clockwise to increase the pressure being applied.

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Gauge B – Inflatable Bag Pressure Regulator

Different sizes of meat may require different air pressure settings for the inflatable bags (varying degrees of inflation). Generally a setting of 30 PSI (210 kPa) is used to expand the inflatable bags.

To set the correct pressure initially and to adjust for varying meat size:

1. Place the cut/meat sample into the rubber sleeve.
2. Using the regulator, back off the pressure setting on Gauge B then begin increasing it until there is squeeze on the meat and it begins to expel from the rubber sleeve.
3. Set the regulator to this pressure setting for subsequent meat cuts of a similar size. Once Gauge B is set use Gauge A to fine-tune pressure required to expel meat.
4. Adjust these settings as required.

Gauge C

This gauge is currently defunct (was used to regulate pressures of a previous system).

Gauge D - Vacuum Pump

This gauge shows the settings for the vacuum pump (which is used to expand the rubber sleeve). Normal settings of the vacuum pump gauge are:

1. Boa idle – stop button out; minus 25 kPa
2. Boa idle – stop button in; minus 55 kPa
3. Stop out, cycle rubber to open/close (no meat) – dial will read minus 55 kPa

To check that operation of the Boa is correct, read the dials with the stop button in both the in and out positions and during the open/close cycle of the rubber sleeve – the dial MUST give the preset values. If not, the vacuum system has a leak - possible causes are;

i. Rubber is split (holes) or not fitted correctly
ii. Hosing is disconnected or leaking
iii. Pump motor not running

If, after checking and repairing any leaks the gauges are not showing the correct values then call Fix All Services.

Gauge E – Pressure Relief

This gauge has been preset with values to protect the rubber sleeve from over-expanding. If the rubber sleeve is over-inflated it could rupture and/or cause other damage thus the relief gauge is set to a maximum allowable pressure.

Set points are 0.700 Bar (700 kPa) and 1.100 Bar. On activation of the relief gauge, a thumping noise can be heard which is air exhausting from the system.

Pressure is relieved by exhausting air from the system if, for example, Gauge A has been turned up too high and too much pressure is being applied to the rubber sleeve. The preset values send a signal to the PLC to open a relief valve and so reduce the pressure.

In some instances it may be necessary to override the set points to be able to temporarily apply increased pressure (for example, extremely large meat portions). <u>Proceed with caution</u> if adjusting these set points as too much pressure may rupture the rubber sleeve. To adjust set points:

(i) Press M button to enter settings.
(ii) The display will flash with 'Lo' and the value 0.700.
(iii) Adjust to required value using the up/down arrows.
(iv) Press M again to show 'Hi' with value 1.100.
(v) Adjust using up/down arrows.
(vi) Press M again to exit.

Levers

There are two levers on the outside of the Boa. These levers are related to an earlier operational function where the meat was squeezed down and out the bottom cavity of the Boa through tube attachments. These levers are now defunct in relation to the current operation of the Boa.

However, one lever is still functional and raises/lowers the mast (Figure 3). With air supply on, push the lever up to raise the mast. Similarly, push the lever down to lower the mast.

Possible Faults

If meat is not expelling from the rubber sleeve possible faults are:

- Leak in vacuum system (hoses, pump faulty)
- Leak in rubber sleeve
- Leaking inflatable bags
- Airlines constricted or disconnected
- Incorrect pressure settings on Gauge A and B

Meat is starting to move into the packaging sleeve but jams:

- Rubber sleeve inserted incorrectly (ridge stopping flow of meat being expelled)
- Air pressure combinations of Gauges A and B incorrect

During operation, if machine is sluggish or not expelling meat or there is an obvious pressure drop:

- Check air supply is connected and the compressor is functioning

If there is no power to the unit, instrumentation and/or Gauge E shows 'Err2' on the display:

- Open the GE Weiss box (grey box unit with Gauge E attached)
- Check the circuit breaker switches are in the 'on' position

9.2 Full Patent guidelines

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 by stretching 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 cylinders connected at one end to the receptacle, and connected at another end to a plate that is attached to the flexible sleeve.

Preferably, the flexible sleeve is a nitrate rubber compound 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 to 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 or using a peristaltic action to remove 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.

Figure 3 shows a further preferred form meat stretching device.

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 nitrate rubber compound sleeve. Of course, other materials may be used instead such as silicon and 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.

Cuts of meat suited for use in this invention include beef, chicken, lamb or goat portions. Meat cuts also include whole gutted fish such as salmon or trout. Meat cuts further include mechanically recovered or reconstituted meat as well as cut portions.

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 nitrate rubber compound 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 extracted from the bottom of the flexible sleeve, the present invention can be worked such that the meat cut 16 is extracted 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 extracted 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 or 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 extract meat that has been stretched by the device. The extracted 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 extracted. 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 extract 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.

Figure 3 shows a further preferred form meat stretching device 300. The device includes an aperture 305 at one end of the device. The device shown in Figure 3 includes a further aperture at the opposite end of the device. The aperture is formed and maintained by a rigid annular flange or ring 310. Ring or flange 310 is formed from a suitable rigid material such as sheet metal.

Disposed against flange 310 is one end of a flexible medium or sleeve 315. The sleeve is held open to form an aperture at one end by ring 310. A further rigid annular flange 320 ensures that the end of the sleeve 315 is held between flanges 310 and 320.

The other end of sleeve 315 is located between similar annular flanges 325 and 330.

The flexible sleeve 310 is disposed within a rigid housing 335. Also disposed within housing 335 are a plurality of flexible ribs. Figure 3 shows ribs 340(R) and 345. As shown in Figure 3 ribs 340(R) and 345 are positioned within housing 335. Each end of each rib is attached to respective ends of the exterior of the sleeve 315.

The ribs in one embodiment are formed from the same material as the sleeve 315. In another embodiment the ribs are formed from a different material.

As shown in Figure 3 the ribs tend to flare out at each end of housing 335 to match the increased diameter of the sleeve 315 at each end. The ribs are positioned at uniform intervals around the interior of the housing in a circular configuration. The circumference of the circle defined by the ribs is greater at each end of the sleeve 315. As shown in Figure 3 in one preferred form the circumference reduces to a constant point and then does not vary further along the interior of the housing 335.

Disposed between adjacent pairs of ribs are a series of inflatable cylinders or bladders. One such bladder is indicated at 340. Other bladders are shown at 340A and 340B. Bladder 340 is shown disposed between rib 340(R) and rib 345.

The ribs have the effect of locating the bladders between adjacent pairs so that the bladders do not undergo undue lateral movement during inflation.

Also shown in Figure 3 is a plurality of extending cylinders. One such cylinder is shown at 350 and another at 355. It is anticipated that the cylinders 350 and 355 are arranged to be shortened or lengthened to vary the distance between the end of the sleeve adjacent to base 330 and the aperture 305. These cylinders can be shortened in order to replace flexible sleeve 315 with a fresh replacement sleeve.

In use, a meat cut is placed within flexible sleeve 315 through aperture 305. Bladders 340, 340A and 340B are inflated. The bladders are constrained from expanding outward by housing 335. The bladders are optionally further constrained by panels 360, 365 and 370. The bladders are constrained from extending laterally by ribs 340(R) and 345.

As the bladders continue to be inflated, the circumference of the sleeve 315 reduces causing the meat to lengthen within sleeve 315. As air continues to be introduced into the bladders 340, 340A and 340B, the ends of the bladders closest to the ends of the sleeve 315 expand to fill the wider circumference around each end of the meat cut. The ends of sleeve 315 are held stretched by the physical constraint of being between flange 310 and flange 320. When there is a gap between the end of the meat cut and flange 330 the sections of the bladders at this end of the sleeve expand to a greater degree than those portions of the bladders which are restrained by the meat inside sleeve 315. . This causes a peristaltic force that urges the meat cut toward the aperture 305. As the meat cut travels along the flexible medium toward aperture 305, the flexible sleeve further constricts around the end of the meat cut closest to the base 330 causing further peristaltic force to be placed on the meat cut.

In this way the use of a piston as described above can be avoided. In the embodiment shown in Figure 3 the meat cut is able to travel along the flexible sleeve with a peristaltic action. It is envisaged that a piston could be introduced as well as the peristaltic action to further urge the meat cut along the flexible sleeve.

It is also envisaged that the bladders could expand to a greater degree at the end closest to aperture 305 which would then have the effect of urging the meat toward the base end of the housing. This means that the meat cut could be introduced into one end of the housing and could be removed at either end of the housing.

The rigidity of the sleeve can be varied according to the type of meat cut selected.

It is envisaged that a packaging medium could be inserted within the sleeve after stretching. This arrangement has the advantage that an additional packaging step is not required.

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 cylinders connected at one end to the receptacle, and connected at another end to a plate that is attached to the flexible sleeve.

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

6. The meat stretching device as claimed in claim 1 wherein a peristaltic action is used remove the meat.

7. 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.

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

9. 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.

10. 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.

11. 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. The method as claimed in claim 8/6 further comprising the step of using a peristaltic action to remove the one or more cuts of meat out of the constricted flexible sleeve.

12. 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.