final report

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Advanced Low Voltage Stimulation

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Executive summary

Smart Stimulation provides a unique combination of automated processing control and quality measurement, and the commercialisation and assessment of the commercial benefits of this technology are underway. At present, the Smart Stimulation technology addresses the whole carcass, but our earlier work found that the responses of the whole carcass are largely dominated by the responses of the M. longissimus dorsi. Measuring the responses of other carcass muscles would have significant commercial advantage. This can be addressed by hot boning and stimulating individual muscles, or alternatively by developing a method of measuring the responses of individual muscles on a carcass. Stimulating individual hot boned muscles has been tried and found to be effective at generating a pH decline, but interpreting the responses as a Smart Stimulation procedure has not been attempted. Measuring the responses of key individual muscle responses on carcasses could be accomplished using image analysis and this approach will be developed for this objective.

This project delivered:

Report on validation of 4 existing Smart Stimulation installations for objective measurement of pH, and/or UpH and/or tenderness.
Report on: i) Pre-dressed carcass Smart Stimulation installation at Riverlands Eltham, a hot boning beef plant in New Zealand, and ii) High throughput, 24 carcasses per min Smart Stimulation installation at PPCS Pareora, a lamb processing plant in New Zealand, and iii) Statistical validity, reliability and quality control outcomes of the 4 (ie 2 x plants in Australia & New Zealand) commercial Smart Stimulation installations as a measure of pH, and/or UpH and/or tenderness.
Develop technology transfer documentation and guidelines including, specifications, data sheets, & materials to hand over to commercialiser on operation of commercial Smart Stimulation systems for beef and sheep. Transfer commercial know-how to commercialiser(s) including Argus Realcold and provide information and assist in reviewing industry-focused trade publication(s) on Smart Stimulation.

Contents

Background

MLA has developed a new generation of electronic meat processing technologies (electrical stimulation, immobilisation, electronic bleeding) using a computer-controlled waveform to give exactly the same electrical “dose” to each carcass. This ”dose” is determined experimentally as the best “dose” for a particular carcass type. Although better than the earlier variable dose stimulation systems, this approach does not allow for variations between carcass of a particular carcass type. A new development pioneered in New Zealand has shown that by using carcass feedback techniques, an optimum “dose” may be delivered on a carcass-by-carcass basis.

The new generation, MLA computer controlled electronic meat systems are now being commercialised and with suitable programming changes this technology could be upgraded with these new carcass feedback techniques to further enhance processing quality as the technology matures.

MIRINZ Inc has sole ownership of the feedback technique at this stage and with the current level of funding there will be some time before the technology is demonstrated in sheep and even longer before beef versions are developed. By partnering MIRINZ Inc, MLA has the opportunity to add value to its existing electronics technologies and fast track the commercialisation of the next generation of electronic processing technologies.

This approach is consistent with the program plan approved for the “New Generation Process Innovation Program” and the program will rely on MDC funding for much of the applied research. The developments in this project will draw on results developed at a strategic level by other researchers funded by industry sources which is consistent with the program model where industry funded theoretical research is fed into MDC funded applied developments.

Electrical stimulation of carcasses has become a standard processing technology for the red meat industry. Originally devised primarily as a means of accelerating the rate of pH decline, to accelerate the tenderisation process, the use of electrical inputs to carcasses now also includes electrical stunning, stimulation and back stiffening. There are two important implications for the use of electrical stimulation of carcasses in the context of current and future processing for quality meat:

- Too much electrical stimulation has important adverse effects on meat quality. Excess electrical inputs produce exaggerated rate of pH decline, and produce meat with poor eating quality, poor colour stability and high purge losses.
- The pH response of carcasses to electrical stimulation is highly variable and unpredictable. This phenomenon is particularly evident in high-value grain fed cattle, where even minimal electrical stimulation can produce exaggerated rates of pH decline

These risks associated with using stimulation technologies need to be weighed against their substantial benefits, relating particularly to processing efficiencies (accelerated tenderisation; reduced damage during hide pulling) and worker safety (carcass immobilisation following stunning). Ensuring high quality and consistency in meat products is increasingly recognised to depend on managing the pH and temperature changes in the carcass post mortem, and the need for stimulation procedures that give the required control over pH changes are becoming increasingly evident.

This programme will develop a new generation of electrical stimulation technology to resolve these issues. Two main strategies will be employed:

1. The waveforms used in electrical stimulation (typically 15 Hz, 10 msec pulses) were designed to produce a maximal pH effect. New waveforms will be designed to produce reproducibly graded pH responses that can be applied according to specified needs
2. Because the response of each carcass to electrical inputs varies, a full control of the pH changes will depend on monitoring the response and modifying the stimulation parameters

accordingly (feedback stimulation). This technology will allow the stimulation to be tailored to the specific needs of each carcass, so as to produce a consistent and predictable pH decline.

The development of the feedback stimulation technology for lambs has received significant funding from Meat & Wool New Zealand (M&WNZ) and is approaching commercial trial stage. Additional benefits identified from the work so far are the ability to use characteristics of the response of the carcasses to stimulation procedures to predict ultimate pH and aspects of tenderness.

Further improvement of the interpretation of the responses of individual muscles to electrical stimulation will be to model muscular responses to electrical stimulation. The contribution of this project will be an interpretative framework to analyse the response characteristics of specific carcass muscles in response to designed stimulation parameters. The objective will be to define the biochemical basis for individual differences in the responses to stimulation and link these with differences in meat quality attributes.

Project Outline

The following are the milestones:

Milestone	Milestone Description
1	Report on validation of 4 existing Smart Stimulation installations for objective measurement of pH, and/or UpH and/or tenderness.
2	Report on: i) Pre-dressed carcass Smart Stimulation installation at Riverlands Eltham, a hot boning beef plant in New Zealand, and ii) High throughput, 24 carcasses per min Smart Stimulation installation at PPCS Pareora, a lamb processing plant in New Zealand, and iii) Statistical validity, reliability and quality control outcomes of the 4 (ie 2 x plants in Australia & New Zealand) commercial Smart Stimulation installations as a measure of pH, and/or UpH and/or tenderness.
3	Develop technology transfer documentation and guidelines including, specifications, data sheets, & materials to hand over to commercialiser on operation of commercial Smart Stimulation systems for beef and sheep. Transfer commercial know-how to commercialiser(s) including Argus Realcold and provide information and assist in reviewing industry-focused trade publication(s) on Smart Stimulation.

Project Objectives

At the completion of the Project, the following was completed :

- Predicting tenderness
- Ultimate pH
- Installation and validation of at least 2 plants in Australia and 2 plants in New Zealand for sheep and beef for predicting tenderness and ultimate pH.
- Full US Patent obtained
- Develop and validate contractile model to interpret the contractile characteristics and predict muscle structure

Experimental work

Milestone 1 & 2 – Review of existing Smart Stimulation (SS) installations

2.1 Auckland Beef Processors – Beef

This installation is based on 2 load cell installed into an existing high voltage stimulation tunnel. The stimulation tunnel is built around the lowerator at the end of the dressing chain and provides up to 90 seconds of stimulation. A switch was installed to allow the system to be operated as either a high voltage or a medium voltage stimulation system.

The primary interest of the plant was to develop an ultimate pH prediction system to reduce the labour costs of chiller pH measurements to meet the requirement of the Quality Mark. The domestic market is the principle end user of the beef from this plant, and a vigorous stimulation system (fast rigor) is therefore the principle objective. The plant preferred to persist with a constant 90 seconds of stimulation to obtain the shortest possible 'retail ready time'.

Two load cells were installed in the rail: one was positioned at the beginning of the stimulation and the second at 30 seconds following the start of the stimulation (the chain speed through the dressing floor is variable, but the speed of the lowerator chain does not vary). A standard 2 load cell SS software programme is used to control the test pulses and acquire the responses from the carcasses. The immobilisation of the carcasses after the stun was converted to a high frequency system to avoid excessive pH decline before the Smart Stim system.

2.2 Australian Country Choice (ACC) – Beef

The installation at ACC underwent significant modification during this year. First, the load cells were changed from a single point to beam type to provide a more stable platform and reduce the risk of distorting the rail. This change appears to have produced better results, and the carcass response measurements during SS were not affected. Two further modifications were to add an extension to the rubbing rail to avoid veal carcasses from twisting over to the wrong side of the electrode, a problem caused by their small size; and adding insulation at the end of the rubbing bar to produce a smoother dismount from the end of the rubbing bar.

The last 2 modifications were only partially successful: the extension of the rubbing bars did not fully control the vealer carcasses and some were found to twist over the rail. A preliminary test to see if the SS control system could be used to differentiate between vealers and full size carcasses was found to be partially successful: by increasing the threshold voltage used to detect the presence of a carcass, the vealers cold be differentiated, but the high threshold voltage meant that the responses of the carcasses to the SS test pulses would occasionally drop below the threshold voltage and incorrectly indicate to the controls that the carcass had left the load cells. The software can be modified to correct for this, although the option to use the medium voltage system to further stimulate the vealers should probably remain open.

A more important problem with the electrode modification was found to be the absence of insulation in the lead up to the first stimulating electrode. This meant that carcasses on consecutive hooks can both be simultaneously in contact with the one electrode at some point during the stimulation cycle and, since this placed two carcasses in parallel on the first electrode, cause the stimulation voltage to drop precipitously and deliver insufficient current to the test carcass. This has been discussed with the plant and they have agreed to correct this fault (completion still to be confirmed), but a temporary insulation was added during the trials to allow the calibration process to begin.

The principle objective of the ACC installation is to manage the pH decline to meet the requirements of the MSA grading system.

2.3 ANZCo Foods; Riverlands Eltham - Beef

The Eltham plant is a hot boning operation and their primary objective is to predict ultimate pH, something that is difficult to do using conventional pH measurements methods. The requirement of the plant was also to undertake the stimulation after hide pulling but before evisceration and carcass splitting. This is a significant deviation from the normal procedure but the opportunity to use SS before dressing increases the range of opportunities for the system.

The throughput of the plant is relatively slow and the stimulation is carried out on a static carcass positioned on a load cell. A pneumatically operated arm makes the electrode contact to the carcass. This electrode system underwent a complete redesign during plant closure to ensure that the contact with the carcass did not break at the start of the carcass stimulation.

The electroimmobilisation after stunning was converted to a high frequency system to avoid excess pH decline before the SS. The immobilisation takes place on a bleeding conveyor using a pneumatically-operated blade that extends to contact the rump of the animal. Consistent with experiences elsewhere, the use of HF immobilisation can result in a backward kick of the hind legs when the contact is first made with the carcasses, which makes continued contact with the electrode unreliable and can mean the carcass is pushed too far forward on the bleed table. This proved to be a particular problem at this plant. To correct for this, the electronics were modified to allow a 3 second period of conventional low frequency immobilisation when contact is first made with the carcass, which prevented the kick out, and the system then converts to a HF waveform for the remainder of the immobilisation period. This modification proved to be successful.

A remote access to the SS control system has been installed. A procedure has been set up with the plant to undertake regular ultimate pH measurements in combination with acquisition of the SS carcass responses. These data are then sent to Carne Tech for analysis and the development of a database.

2.4 Auckland Meat Processors – Sheep

This system provided 50 seconds of stimulation using an 8 segment stimulation rail and 4 load cell test sites. The plant throughput is a fairly average 6-7 carcasses/minute. The principle objective is to manage pH decline for a local market.

A high frequency immobilisation system was installed after stunning to avoid excessive pH decline before the SS. However, because of the higher muscle pH’s at the SS, managing the bouncing of the carcasses at the SS electrodes introduced some difficulties. These were largely controlled by adding, at the first stimulation segment, a hinged electrode arm perpendicular to the main stimulation rail. This arm folded back as the carcass was dragged over the first segment, but had the effect of maintaining electrification of the carcass when it bounced, and avoided breaking the contact with the main electrode during the relaxation stage of the carcass contact during the test pulse. Some further modifications of this system were necessary at the start of this season when the smaller lamb carcases appeared, as these proved particularly jumpy. These small carcasses also identified that the width of the insulation between the segments could have the effect of reinitiating carcass bouncing as they (or any carcasses with a narrow point of contact with the rubbing electrodes) could relax sufficiently during the transfer between segments to allow relaxation and contraction, reinitiating the bounces. Narrow insulators between segments may help to prevent this difficulty and will be retrofitted at some stage.

2.5 Silver Fern Farms (SSF); Pareora - Sheep
This plant has 2 chains operating at up to 10 carcasses/minute, and these converge to a single stimulation tunnel. Taking into account the higher chain speed through the tunnel, this meant a 25 segment rubbing bar, using 4 load cells at 15 second intervals. The principle plant requirement from the SS system is ultimate pH prediction, with the intension of avoiding high pH carcasses, with their associated low storage life, entering into the export chilled lamb consignments.

Because of a number of additional new technologies that are being tested in the plant, including an electronic skid ID system, the plant provided an interface between the SS data and the plant database. The information calculated from the SS is transferred to the database, which then links it with the carcass skid ID. Any requirement to control the stimulation levels by turning off specific segments for a designated carcass is also controlled by the plant PLC. Modification of the software was made to allow the responses of the carcasses, as well as the SS predictions to be linked to the carcass ID in the plant IT system (carried out under milestone 3 of PSH 0341 – Smart Stim data capture project) .

The immobilisation of carcasses after stunning was converted to a HF system. Again, as a result, there were difficulties with bouncing carcases at the start of the SS stimulation, which was corrected with an additional flexible arm electrode. This is undergoing a further modification to accommodate the smaller new season lambs.

Data analysis
The load cell responses were converted to the frequency spectrum using a Fast Fourier Transform (FFT) and the power in the frequency bins were correlated with the pH measurements using Partial Least Squares (PLS) regression procedure in MINITAB. In all analyses, cross validation was used to define the optimum number of components for the predictive model, and used to define the r2 value of the calculated predicted values. This procedure explicitly calculates the accuracy of prediction of data outside the dataset used to define the correlation coefficients by systematically removing each data point from the regression calculation, then calculating the accuracy of the resultant prediction.

1. Smart Stimulation: Review of existing Smart Stimulation installations (Milestones 1 & 2)

1.1 Control of pH decline during and after stimulation

1.1.1 Australian Country Choice (ACC)

Two separate calibration trials were undertaken at ACC. The fault with the insulation on the electrode extension was not recognised in the first trial and, since the current flow could be as much as half the required magnitude in some carcasses (whenever two carcasses were in contact with the same electrode), the results of the trial were disregarded.

A second trial produced a calibration for carcass pH decline, the prediction coefficients were added to the SS control system and a run of the full system was carried out.

The calibration was based on 177 carcasses over three separate sessions. Different durations of stimulation were delivered to provide a range of post-stimulation pH levels and rates of decline. Carcass pH's were measured in the m. longissimus dorsi (LD) at the quartering cut immediately after the stimulation. A second pH measurement was made 1 hour later in the chillers (from 159 carcasses) to provide an indication of the subsequent rate of pH decline.

Post stimulation pH values were predicted with an r2 of 0.62 and the 1 hour pH value with a prediction r2 of 0.70.

The carcass responses at ACC continued to show a much higher contraction/relaxation rate compared with NZ cattle, presumably reflecting a different fibre type characteristic arising from either the Bos indicus genetics and/or the feedlot production system. The test pulses were modified to have more of a high frequency to reflect this, and this also had the benefit of reducing the magnitude of the physical responses produced by the test pulses.

The predictions generated by the calibration process were very encouraging, particularly when considering the inaccuracies associated with direct muscle pre-rigor pH measurements. The next stage, expected to be completed in February, will be to validate the predictions by fully commissioning the Smart Stimulation system and demonstrating the benefits for the control of pH decline.

1.1.2 Auckland Meat Processors - Sheep

The SS system at AMP has been used as a primary test site for a range of developments in the SS system. This includes modifications to the software, test pulse characteristics and stimulation waveforms. A number of modifications and improvements in the software controls were identified and implemented.

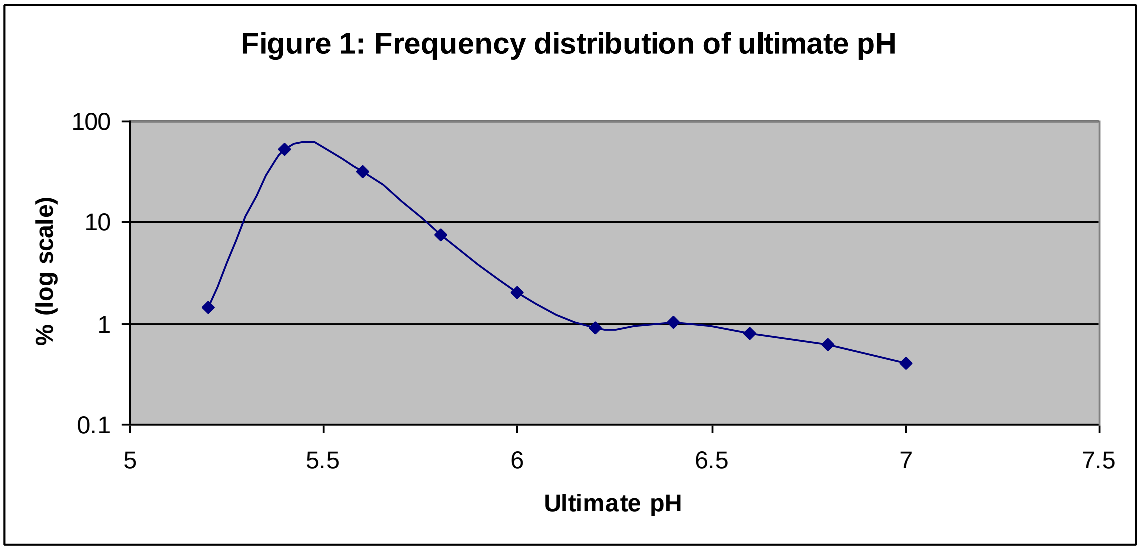
Across a range of different trials and stimulation conditions, the r2 of the pH prediction and control found with the SS system currently range between 0.6 and 0.7.

1.2 Ultimate pH prediction

1.2.1 Auckland Meat Processors

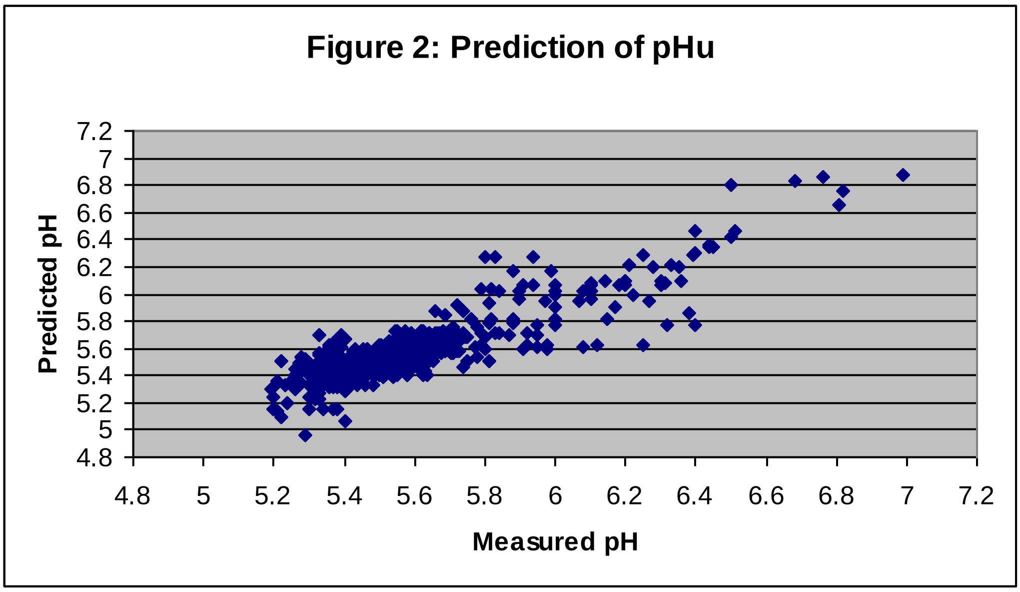
Samples of LD were collected from prime cattle approximately 1 hour after Smart Stimulation. The samples were snap frozen in liquid nitrogen and returned to the laboratory frozen. Within 2 days of collection, the samples were thawed and incubated at 37°C for 30-40 minutes hours, the sample homogenised in distilled water and then the pH of the samples measured with a probe pH meter to determine the ultimate pHs.

Between 70 and 100 carcasses were tested in this way on 17 separate occasions through the year. This generated a total of 1087 pH measurements combined with carcass responses over the two load cells. From this dataset, 9.2% were greater than pH 5.8, producing a total of 142 high pH samples.



The prediction of ultimate pH based on the whole dataset was r2 0.41 when predicted from responses at the first load cell. This value is too low to offer a useful commercial application.

However, some further analysis found that a proportion of carcasses showed weak responses at the initial test load cells. The weak responses were calculated as the total power of the frequency spectrum (sum of the power in each frequency) There were 86 such carcasses (8%) and removing these from the data increased the predictive power of the responses to a predicted r2 of 0.64 (Figure 2).



The reasons for this effect of the weak responding carcasses are currently being investigated. The most likely cause can be attributed to these carcasses having a low pH when they reach the stimulation tunnel: this can be attributed to carcasses with unusually rapid glycolysis, additional stimulation during post-stun immobilisation (which can happen if there are problems with movement or the carcass when it misses the HF immobilisation), or extended periods on the detain chain. These are all relatively common occurrences at this plant.

1.2.2 Riverlands Eltham - Beef

The key distinction in the SS system installed at this plant is the early application of the stimulation, before evisceration or carcass splitting. The stimulation is a static system, which allows an individual carcass to be stimulated to completion at a single station, and this has the benefit of allowing the time interval between the test pulses to be software controlled, rather than defined by the positioning of the load cells (as is the case in all the continuous moving chain systems).

Commissioning the system was delayed by difficulties in getting the post-stun immobilisation system working effectively (as described above) and then, as a result of greater responsiveness caused by the higher carcass pH's, the need to modify the stimulation electrode to ensure that contact was maintained. This last change was made during the plant shutdown in October, and initial validation was begun at that stage.

The results of the work so far show that the carcass responses to the test pulses are noticeably different in whole carcasses compared with dressed split carcasses. However, the responses show consistency when comparing sequential responses within a carcass (Figure 3; showing the gradual weakening of the responses to the test pulses), and the general pattern is sufficiently reproducible between carcasses (Figure 4) to suggest that the responses are not obviously affected by artefacts.

At this stage, the database is under development in collaboration with the plant. On a weekly basis, the carcasses responses are collected and plant personnel simultaneously measure ultimate pH and record carcass data. Because a continuous record of test responses are produced at 10 second intervals from each carcass, a more accurate picture of the contraction responses can be generated and this has the potential of overcoming the limitation of only 2 responses from the AMP installation.

Figure 3: Sequential responses to test pulses from a carcass

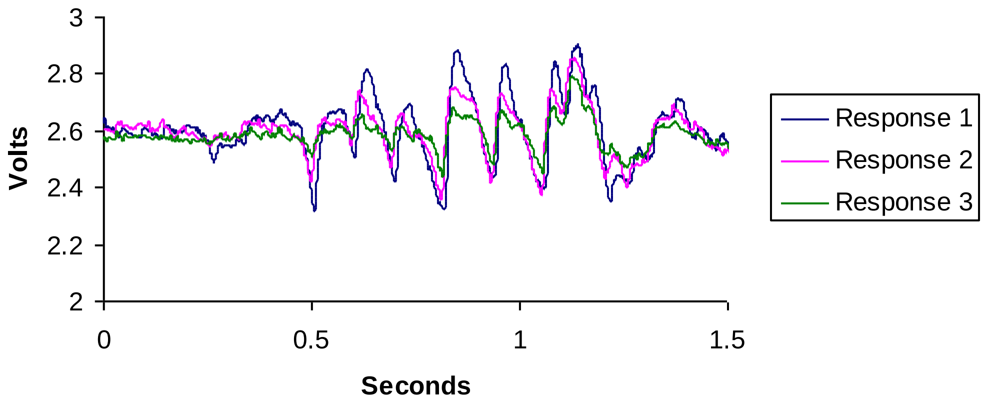
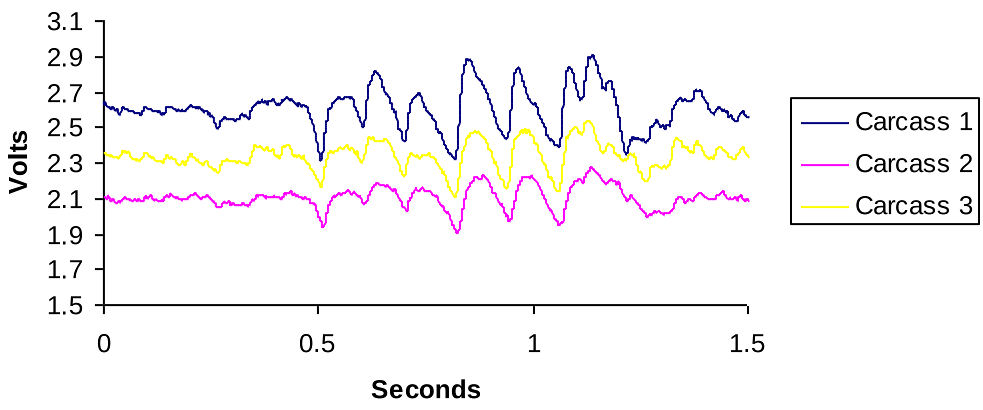


Figure 4: Reponses of individual carcasses to test sequence 1



The overall shear force has improved significantly since the SS system was installed. Like SFF, Riverlands operate a weekly meat quality audit including shear force testing, and these have produced a lower mean shear force and a reduction in the standard deviation of the population compared to their previous immobilisation and stimulation system (15Hz low voltage immobilisation followed by 60 seconds of low voltage stimulation) on each occasion. Furthermore, the purge loss in the vacuum bags after 14 days of ageing is significantly lower and the colour stability of steaks from the striploin has improved by 1-2 days at each test. These results were recently confirmed in a meat quality evaluation of the system conducted by CT.

1.2.3 Silver Fern Farms; Pareora - Sheep

Ultimate pH prediction in lamb carcasses is the principle objective for Pareora, with the view of reducing the risk of introducing high pH meat into the chilled export trade.

The plant runs 2 chains that, potentially, can operate in excess of 10 carcasses/ minute, so the plant provided a very useful test of the SS system in very high throughput conditions. In particular, each load cell is separated by 5 stimulation segments, so reliable tracking of the carcasses through the 30 seconds of stimulation was a test for the system.

Once the medium voltage system was commissioned, the plant required an evaluation period to ensure that the medium voltage stimulation system would be able to match the earlier high voltage system in terms of lamb tenderness and ensure that the AC & A specification could still be met. This was carried out via the plants' weekly meat quality auditing system over several months; the high frequency immobilisation in combination with the medium voltage system produced significantly lower shear force values (improved tenderness) compared to their previous AC & A system (low voltage, 15Hz immobilisation followed by high voltage stimulation).

Two software problems were identified in this SS installation, both relating to tracking the carcasses during the 'invisible' period between the load cells. These have now been corrected. In addition, a further modification of the software was made to allow the responses of the carcasses, as well as the SS predictions to be linked to the carcass ID in the plant IT system. This step has greatly facilitated the calibration process since carcasses can be retrospectively selected in the chiller and the SS responses identified through the database. The alternative, to pre-select and tag specific carcasses before stimulation, is a reasonable option in relatively slower throughput plants but created a significant logistical problem in a high throughput plant such as Pareora.

Since the start of the new season, a procedure to control carcass bouncing has proved to be insufficient, partly because of the smaller carcass sizes but also because of a general increase in the responsiveness of the carcasses. This second point is surprising since all aspects of the carcass processing, including the immobilisation following the stun, have remained unchanged from the previous season and seems to imply that the responsiveness of the carcasses has a significant seasonal or environmental influence. A continuous monitoring of the performance of the SS through the season can be expected to provide some insight into the nature of this phenomenon.

1.3 Tenderness prediction

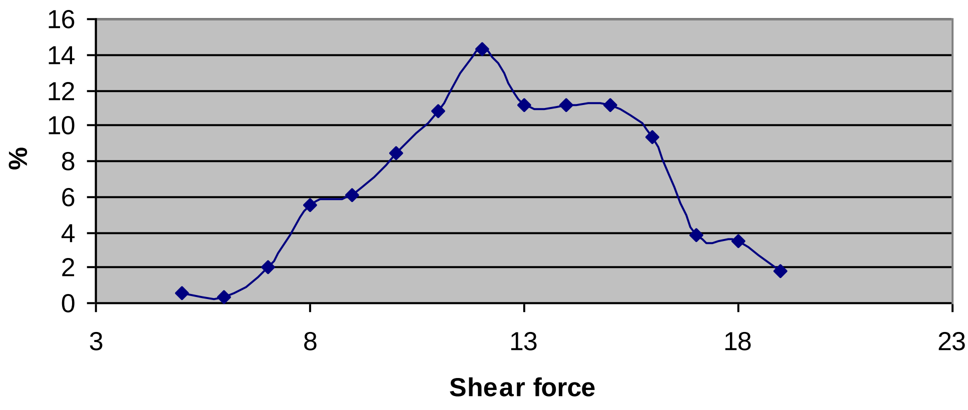
1.3.1 Auckland Meat Processors

Tenderness measurements were made from a total of 562 prime carcasses collected on 17 separate occasions. This ensured not only a much larger database than previously but, by distributing the collection over much of the year, ensured that seasonal and other potential variables are incorporated.

Typically, around 30 samples were collected on each occasion. After the carcasses were passed through the SS system and carcass responses collected, the carcasses were chilled normally. The next day, a section of LD was collected in the boning room and held on ice until the sample was returned to the laboratory. At 24 hours post slaughter, the samples were cooked and tenderness assessed using the Tenderometer.

A wide range of shear force values were measured, as shown in the frequency distribution of shear forces in Figure 5.

Figure 5: Frequency distribution of 24 hour shear force values



The results found a poor prediction of tenderness using the SS system. Overall, a predicted r2 of only 0.22 was possible, too low to offer any meaningful commercial opportunities.

The failure to replicate more promising earlier results, based on a smaller sample size, could be attributed to the greater diversity of samples included in this latest database. However, some further investigations of the tenderness predictions will take place as part of the database development from the Eltham installation, where the routine QA tenderness measurements will be included in the SS database. Similarly, on-going tenderness measurement will continue as part of the SS trials over the next few months.

2. Support documentation for the current technology (Milestone 3)

Details of the 3 main components of the smart stimulation system have been documented:

- Electrical stimulation system
- Carcass response and acquisition component
- Control system for interpretation of carcass response and subsequent control of stimulation

The installation of the hardware for each commercial installation (rail segmentation, load cell installation and, where applicable, electrode design), are plant dependent and experience to date has shown that these vary considerably depending on the details of the rail (if already in existence), throughput and the outcomes required by the plant. However, once the basic installation details have been defined, most plants should have the engineering capability in house to manage this component of the system.

The principle components of the Smart Stimulation system are:

1. Electrical stimulation component
2. Carcass response acquisition component
3. Control system to interpret responses and control stimulation.

2.1 Electrical stimulation component

The electrical stimulation of carcasses in the Smart Stimulation system requires the following components:

1. Programmable delivery of stimulation pulses in response to instructions from the control system.

   The carcass stimulation uses a conventional 15 Hz stimulation frequency.

   A second aspect of the system is the ability to deliver test pulses to the carcasses at the appropriate time in response to instructions from the control system. The test pulses comprise 9 pulses, delivered as triplets with increasing pulse intervals. These are typically 90, 120 and 150 msec.

Following the delivery of the test pulses, the 15Hz stimulation resumes or ends in response to instructions from the control system.

A minimum of 60 seconds of stimulation rail is required.

2. The electrical output to the carcasses is controlled on an individual carcass basis (where control of pH decline and duration of stimulation is the objective; prediction of ultimate pH does not require individual carcass control of stimulation). On a continuously moving chain, the stimulation rail is segmented to apportion one carcass to each segment.

   The delivery of stimulation voltage to each segment is managed by the Smart Stimulation control system.

   A minimum of 1 Amp peak pulse amplitude and either 1 msec (beef) or 5 msec (sheep) pulse width is required to be delivered to the carcass during stimulation.

   The preferred orientation of the carcases is to have the musculature in contact with the stimulation electrodes in split beef carcasses and the back in contract with the stimulation electrodes in whole dressed lamb carcass.

3. The output from the stimulation system needs to be controlled by the Smart Stimulation controller. Control lines consist of:

   - Output to each segment on/off
   - Start test pulse sequence

2.2 Carcass response acquisition component

Carcass responses to the test pulses are acquired through load cells embedded in the support rail. The details of the load cell configuration are closely linked to the chain speed. Two conditions define the span of each load cell and the spacing between intervals:

1. A load cell will span a stimulation segment, or a minimum of 3 seconds of the total duration that a carcass is positioned over a segment.

2. The test pulses are delivered to the carcass at a maximum time interval of 15 seconds.

(See photographs 1 – 3 below)

In slow beef plants with static stations, a single load cell can provide the required 60 seconds of stimulation. In one such installation, a purpose built electrode has been developed supplying both the stimulation and test pulses to the carcass at the static station. See attached video.

In high throughput sheep plants, up to 25 segments may be required and 5 segments (potential 5 carcases) between each load cell.

The load cells can be the single point- or beam-design. A specialised design of load cell is not required. The responses to the test pulses can double the apparent weight of the carcasses, so a 300-400% overload specification is recommended.
Load cell conditioners need to be selected to avoid dampening electronics, which will attenuate high frequency components of the responses. The PT350C (Chi Mei Electronics Company Ltd) has proved to be effective.

Beef load cells are calibrated to 1V / 50 kgs, and sheep load cells to 1V/10 kgs.

1.3.2 Photographs from one of the commercial lamb installations

Photo 1. Load cell fitted into the overhead rail

Photo 2. Rail segmented into electrically isolated 8 sections (stimulation sections and 4 test pulse sections) using insulating blocks. Recent installations have shown that these blocks should be no wider than 20mm to avoid issues with carcass bouncing.

Photo 3. Lambs on the 4-load cell Smart stim system

2.3 Control system

The control system is a PC-based LabView programme which interfaces through a National Instruments PCI6220 M series A/D card. The system accepts inputs from up to 8 load cells and can provide control lines for up to 25 segments.

The load cell conditioners are positioned near the load cells and the amplified signal transmitted to the PC. An environment outside the production area would allow a conventional desktop PC to be used as the control system, but an industrial PC can be used in the production environment.

A new version of the control system is currently under development. This will use a bespoke PCB control card that manages each load cell and can be increased, as modules, if the number of load cells increase. This system will use industrial electronics to permit operation in a hostile environment.

The architecture of the two control systems is essentially the same. A simple flow diagram is presented below:

1. Load cell carcass detect → 2. Pre-test stimulation period → 3. Initiate test pulses → 4. Acquire load cell responses to test pulses → 5. Calculate carcass attributes → 6.a. Maintain / discontinue electrical stimulation to test carcass; 6.b. Transmit calculated carcass characteristics to specified database → 7. Recycle test pulses after used-defined time interval – return to 2.; or: detect movement of carcass off the load cell – return to 1. → Track individual carcass through to next load cell; maintain stim/no stim condition through remaining stimulation segments.

The Smart Stimulation system is currently used for control of pH decline during and after stimulation, and for the prediction of ultimate pH in the carcass. Interface with existing plant IT systems is expected to be carried out on a plant by plant basis, depending on their specific requirements and the nature of their IT system.

2.4 Calibration of the Smart Stimulation system

The transformation of the load cell signal into a prediction of pH or ultimate pH in the carcass is based on converting the signal into the frequency domain using Fast Fourier Transform, then developing a regression equation between the power in the frequency bins with the carcass attribute of interest. Calibration of the system therefore depends on defining coefficients used to convert the frequency values of the load cell responses into carcass attributes.

The transportability of the coefficients between plants is still under investigation. For the present, a new set of calibrations are likely to be needed for each new installations. A dataset based on 100 carcasses is likely to be a minimum requirement to establish a calibration for a new installation.

Conclusion / Commercial

The SS system to predict ultimate pH in cattle requires that the carcasses reach a minimum level of responsiveness before an accurate prediction can be made. A key requirement at this stage is to show that low responding carcasses can be differentiated from carcasses with low muscle glycogen levels. The existing data is being reanalysed to look for possible explanations and identify strategies for both managing the weak responding carcasses and improving the overall predictions.

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