final report

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Development of electrode assemblies and electronics to facilitate in plant adoption of Smart Stimulation

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Executive summary

Pilot trials have demonstrated the CPMS Smart Stimulation works successfully for beef and sheep meat. The purpose of the project is to facilitate adoption of both one beef and develop a new generation of electrical stimulation technology. This Project proposes to develop 1 beef and 1 sheep meat commercial process by making the minor necessary adjustments to ensure the process can run over normal processing conditions. Also systems are to be developed and setup to provide plants with operating manuals, service manuals and routine QA procedures for ongoing validation. This project will also address all elements of setup and ongoing monitoring.

To overcome the industry hurdles and assist later with full market penetration of new Smart Stimulation technology(s) in a reasonable time scale, it is proposed that MLA and the commercialiser enter into a partnership agreement to pay the salary, travel and operating costs of one part-time technical officer (approx 30%) from the commercialiser for an initial period of 12 months.

No report is required. Project outcomes will be used by the commercialiser to refine future commercial installations.

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 carcase. This ”dose” is determined experimentally as the best “dose” for a particular carcase type. Although better than the earlier variable dose stimulation systems, this approach does not allow for variations between carcases of a particular carcase type. A new development pioneered through the joint MQS program between MLA and Meat & Wool New Zealand has shown that by using carcase feedback techniques, an optimum “dose” may be delivered on a carcase-by-carcase basis.

The pH response of carcasses to electrical stimulation is highly variable and unpredictable. 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. 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.

On-line pH measurement will be possible using this dose-controlled Smart Stimulation System. This may be achieved by first measuring carcase movement on a load cell in response to electrical inputs.

The first Smart Stimulation installation in Australia for beef is now completed and the first installation for sheep meat will be completed by March 2007. While commercial trials have successfully demonstrated initially on beef that Smart Stimulation provides the optimum stimulation dose for each carcase, thereby reducing eating quality variations across entire production batches, processors have been reluctant to operate commercially across an entire shift due to mechanical issues in processing large variations in carcase sizes between vealers through to prime cattle.

There are a number of expected mechanical and electrical modifications that will be required on the first beef and sheep meat installations to meet the specific processor’s needs so that the system can operate commercially allowing greater data collection and therefore greater accuracy of the overall system. This is a major hurdle for adoption of Smart Stimulation.

The Smart Stimulation technology has been developed to an advanced prototype level and demonstrated in that form on a limited number of processing chains. To facilitate wide spread uptake of the technology for beef new commercial grade, electrode, load cell and electronics designs need to be tested in a commercial environment for the first beef and sheep meat installations to demonstrate the technologies commercial viability and allow data to collected.

Being the first proposed installation of its type with beef and sheepmeat processing, there are a number of modifications required to existing equipment to permit the measurement components of the Smart Stimulation system to work freely and yet have the required support to carry a jigging beef carcase upon stimulation. The current project proposes to address the mechanical and electrical requirements for a Smart Stimulation system to operate commercially across normal production cycles within existing processes.

In addition, 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. 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. Therefore, R&D resources are also required to validate systems once implemented and commercially operating.

The current proposal will facilitate adoption of both one beef and develop a new generation of electrical stimulation technology to resolve these issues. To overcome the industry hurdles and assist later with full market penetration of new Smart Stimulation technology(s) in a reasonable time scale, it is proposed that MLA and the commercialiser enter into a partnership agreement to pay the salary, travel and operating costs of one part-time technical officer (approx 30%) from the commercialiser for an initial period of 12 months.

Project Outline

The following are the milestones:

Milestones
1. Modify existing systems where required project management. Installation supervised by plant and project management & processor agrees to commercial processing using Smart Stimulation.
2. Initial pH decline testing. System operating on optimal settings, primary validation completed.
3. Ongoing pH decline testing and meat quality validation. Ongoing validation completed, plant testing Smart Stimulation routinely as part of normal QA procedures.
4. Project complete, plant commercially operating and testing routinely.

Project Objectives

The objectives of the project are:

1) Undertake mechanical and electrical modifications to the first existing beef and sheep meat installations where required to allow the systems to operate commercially between required batches;
2) Facilitate adoption of new Smart Stimulation through on-plant R&D trials and preliminary validation;
3) Facilitate validation of quality and meat quality of product being processed using Smart Stimulation on a routine basis; and
4) Develop documentation from existing information to support ongoing adoption and maintenance of Smart Stimulation.

Experimental

The following method is proposed for the first Smart Stimulation plants for beef and sheep meat :

- Designs and existing installations approved in advance by project management.
- Undertake mechanical and electrical modifications including electrode assemblies, load cells and electronics installed and tested where required, and installation supervised by plant and project management.
- Validation

  i) Primary validation – verify optimal settings based on pH decline window
  ii) Ongoing validation - Verified reduced variability in eating quality (at least reduction in variation of pH decline at 10% or more); meat quality measurements, develop routine in plant procedures for monitoring pH decline and ultimate pH to collate in the database.

Outcomes

- Mechanical and electrical modification to existing Smart Stimulation systems for the first beef and sheep meat installations where required to operate across normal expected production batches

- pH decline & UpH data collated from primary and secondary validation testing provided to Carne as part of Joint MQST project investigate ALVS for tenderness and UpH prediction.

- Develop routine QA procedures for plant to routinely monitor pH decline and UpH as part of normal QA procedures, ad data provided to central database on ongoing basis;

- All new installations will be supported by documentation for safe operating and maintenance of meat electronics equipment

Conclusion

- New developments in optimising existing meat electronic systems are happening all the time. In addition, new technologies continue to be developed and optimised, and the first new Generation 2 technology is available now and will need R&D support to enable ongoing plant adoption.
- This proposal is to assist in accelerated uptake of new developments in meat electronics for an initial 12 month period. With other new developments currently in the pipeline, ongoing support is expected beyond this initial 12 month trial period.

Recommendations / Commercial

To overcome the industry hurdles and assist later with full market penetration of new Smart Stimulation technology(s) in a reasonable time scale, it is proposed that MLA and the commercialiser enter into a partnership agreement to pay the salary, travel and operating costs of one part-time technical officer (approx 30%) from the commercialiser for an initial period of 12 months.

No report is required. Project outcomes will be used by the commercialiser to refine future commercial installations.

Appendix A – Commercial facts sheet

CONTROLLED DOSE ELECTRICAL STIMULATION AND IMMOBILISATION OVERVIEW

Realcold Milmech Pty Ltd has the commercialisation rights of controlled dose electrical stimulation and immobilisation, in conjunction with Meat & Livestock Australia and Applied Sorting.

Since the inception of this technology in December 2002, Realcold Milmech has successfully completed installations in both the beef and sheep industries resulting in providing consistent product quality to the end user.

The success of the roll-out of this technology has been enhanced by the endorsement of supermarket chains in that their product quality improvement is measurable.

V&V Walsh are a financial contributor to the original technology trials and have made a decision to install the mid-voltage electrical stimulation technology into their plant situated in Bunbury, Western Australia and commissioning is expected to be completed in February 2005.

PROCESS OVERVIEW

Ageing and tenderness of meat:

Muscles derive their energy from glycogen, which during exercise is broken down into energy and CO_2. In living muscles the pH remains just above 7.0, but can vary between 7.0 - 6.4 during exercise.

After death, the breakdown in glycogen leads to lactic acid because of the absence of oxygen. With blood flow having ceased the lactic acid cannot be removed. Thus the lactic acid gradually accumulates, and the muscle becomes more acidic with a lower pH.

Without any intervention either:

An ultimate pH = 5.5 is reached at which point the cell becomes too acidic for cellular enzymes to continue functioning and the residual glycogen remains in the muscles.

Or, all available glycogen in the cell is used up before the pH has fallen to 5.5. Without the fuel the cell ceases to function.

At these situations, the muscles are still and the animal is in rigor.

The MSA tenderness criteria determine that the glycogen decline/lactic acid formation needs to lower the pH to 6.0 with the muscle temperature between 35°C and 12°C, followed by standard ageing. This means that the time and temperature needs to be controlled to ensure that a pH = 6.0 is achieved within this "window of opportunity".

Outside of this "window of opportunity" two conditions can apply:

1. Animal's muscles pH reaches 6.0 at temperatures above 35°C and "heat shortening" occurs.
2. Animals' muscles pH does not reach 6.0 before the muscle temperature has fallen below 12°C and "cold shortening" occurs.

Hence there is a need to intervene and control the onset of rigor so that:

- Tender meat is produced without having to construct extensive facilities to allow the meat to age rapidly.
- Cold shortening/heat shortening and other problems are avoided.

The standard intervention system has been the application of electrical stimulation, post slaughter, as an electrical current applied to the carcass.

This application of electric current mimics the natural contract – relax signals in living muscles and this accelerates the breakdown of glycogen and accelerates natural ageing enzymes and the onset of rigor.

This intervention is important for:

the chilled meat trade to provide a consistent and correct level of tenderness for local trade. For export trade, the natural ageing rate is very slow at 0°. Hence, during transport it cannot be relied on to produce consistent and correct tenderness particularly if the initial processing time/temperature regime was not correct.

For the frozen meat trade, the natural ageing process is halted when the meat is frozen. Furthermore, if the meat is rapidly chilled and cold shortened this can interfere with the ageing enzymes. Thus the meat will be tough on thawing unless it has been correctly stimulated prior to freezing.

In an overall situation it has been possible to achieve accelerated ageing within normal processing sequence using electrical stimulation. However it has not been possible to guarantee that each individual animal has been correctly stimulated to achieve the optimum tenderness.

This is because the existing systems:

- Do not control the dosage of electricity each carcass receives.
- Do not have the facility for varying and adjusting the waveform.
- Do not measure the individual animal resistance to be able to control the stimulation.

The MLA systems developed have overcome these problems, with controlled dose technology.

The system controls the dosage each animal receives by:

- Segmenting the system so that each carcass is monitored individually.
- The feed back from monitoring allows the dosage and timing to be adjusted for that carcass.

The waveform is adjustable in such a manner as to allow use of narrow pulse widths, which allows use of higher currents that still remain safe. This allows more energy input to the carcass.

The system measures the carcasses resistance and this measure gives the feedback enabling control of the dosage. This is done by applying small test pulses to each carcass.

There are differing forms of electrical energy inputs available which have differing applications such as mid-voltage stimulation, low-voltage stimulation, high frequency immobilisation, low frequency immobilisation and electronic back stiffening - all having an effect on product quality.

With electrical stimulation the rate of pH fall can now be controlled with the rate being affected by:

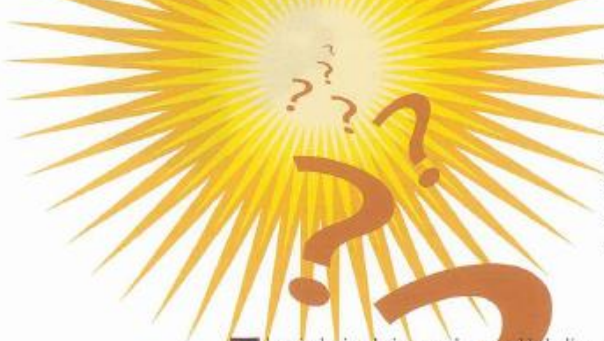
- How long after slaughter the stimulation is applied.
- The magnitude of the applied current and duration of application.
- The waveform of the applied current.
- Other electrical inputs to each animal, (eg. "Stimulation" is the total effect of all electrical inputs – not just the stimulation system alone).

High frequency immobilisation:

This system utilises a high frequency waveform, which activates the nervous system and renders the animal in a relaxed, limp state. The advantage of this system is that there is no effect on ecchymosis or the tearing of the muscle structure, (as caused by the existing immobilisers in use today), with no adverse effect on the rate of pH decline, (major cause effecting meat quality), which has the added advantage when processing grain fed animals.

Appendix B – Commercial publication

Taking the guesswork out of electrical stimulation



New technology jointly developed by Realcold Milmech in conjunction with Applied Sorting Technologies and Meat and Livestock Australia (MLA) has taken the guesswork out of applying electrical stimulation to cattle and sheep carcasses. The system is already operating in a number of sheep and beef plants throughout Australia.

Electrical stimulation accelerates pH decline, the onset of rigor mortis and the natural ageing process. This allows meat to reach an acceptable eating quality in a significantly shorter period of time and can alleviate problems caused by the faster chilling of carcasses. The challenge for processors is to match the level of electrical stimulation (ES) to the rate of chilling and the time the meat is scheduled to reach the consumer.

Muscles derive their energy from glycogen, which during exercise is broken down as a fuel producing lactic acid. In living muscles the pH remains just above 7.0 but can vary between 7 and 6.4 during exercise.

After death, the breakdown in glycogen to lactic acid continues, but with blood flow having ceased the lactic acid cannot be removed. Thus the lactic acid gradually accumulates and the muscles become more acidic with a lower pH.

Without any intervention either:

- An ultimate pH of 5.5 is reached — at which point the cell becomes too acidic for the cellular enzymes to continue functioning and the residual glycogen remains in the muscles; or
- All available glycogen in the cell is used up before the pH has fallen to 5.5. Without the fuel the cell ceases to function.

At these situations, the muscles are still and the animal is in rigor.

The MSA tenderness criteria determine that the glycogen decline/lactic acid formation needs to lower the pH to 6.0 with the muscle temperature between 35°C and 12°C, followed by standard ageing. This means that the time and temperature needs be controlled to ensure that a pH of 6.0 is achieved within this 'window of opportunity'.

For any given chilling rate, too much ES results in too rapid a pH decline. If pH 6 is achieved at a temperature above 350°C 'heat shortening' occurs and the natural ageing enzymes are destroyed. With inadequate ES where the carcass does not reach pH 6 before the temperature falls below 120°C, 'cold shortening' occurs and ageing of the meat is delayed.

The standard intervention system has been the application of electrical stimulation, post slaughter, as an electrical current applied to the carcass. This application of electric current mimics the natural 'contract/relax' signals in living muscles and this accelerates the breakdown of glycogen and serves to hasten the onset of rigor.

This intervention is important for:

- The chilled meat trade to provide a consistent and correct level of tenderness for local trade. For export trade, the natural ageing rate is very slow at 0°. Hence again during transport it cannot be relied on to produce consistent and correct tenderness, particularly if the initial processing time/temperature regime was not correct.
- For the frozen meat trade, the natural ageing process is halted when the meat is frozen. Further, if the meat is rapidly chilled and cold shortened this can interfere with the ageing enzymes. Thus the meat will be tough on thawing unless it has been correctly stimulated prior to freezing.

The effective level of ES is a function of the carcass type and the total electrical load applied to the carcass during the slaughter process. Electrical inputs can come from immobilisers, bleeders, back stiffeners and stimulators with the effect of each depending on the voltage, its duration and the waveform.

The new system accounts for the total electric load (including immobilisation and back stiffeners etc) and can be adjusted on the basis of the ideal electrical inputs for particular carcass types. Its main feature is its use of test pulses to determine the resistance of a carcass and the use of this information to apply the same, precise electrical dose control to all carcasses. The optimal pH decline for any given chilling rate can then be obtained to maximise the benefits of rapid ageing.

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