final report

Project code: P.PSH.0269

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Date submitted: September 2007

PUBLISHED BY
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Advanced Low Voltage Stimulation [125D]

This is an MLA Donor Company funded project.
Meat & Livestock Australia and the MLA Donor Company acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Executive summary

The specific contraction characteristics of a muscle are defined by the responsiveness thresholds of the individual fibres and their calcium handling characteristics. In turn, these attributes are largely defined by fibre size (large fibres have a lower threshold to electrical stimulation than small fibres) and fibre type characteristics (fast twitch vs slow twitch fibre types).

The Smart Stimulation programmes has identified that a number of important meat quality attributes can be predicted by their responses during electrical stimulation. At this stage, the Smart Stimulation system does not attempt to interpret the physiological differences that underlie response characteristics, but uses instead a direct correlation between responses and meat quality attributes of interest. Nevertheless, understanding the underlying physiology offers some opportunities to enhance the Smart Stimulation system and provide a link between live animal attributes and their subsequent meat quality.

To this end, we have been developing a muscle contraction model that can be used to interpret contraction characteristics of post mortem muscles. The muscle responses are measured directly using intramuscular pressure and a range of stimulation protocols can be implemented to characterise differences in the response characteristics. The objective therefore is to interpret muscle response characteristics in order to identify differences in calcium handling attributes (described in the model as fibre type characteristics) and fibre size composition (described in the model as differences in the rate of recruitment of muscle fibres).

There are three parts to the current study :

- Using muscles of different fibre type characteristics, evaluate the ability of the contractile model to interpret the contractile characteristics and predict muscle structure (Milestone 5).
- Complete installation, commissioning and calibration of smart stimulation at Hardwick's and ACC (Milestone 7)
- Provide a report summarising work to date on the smart stimulation technology (Milestone 8)

A review of the current status of the project is that currently 4 commercial installations (ie 2 beef, 2 lamb). These installations are being used to generate data that is critical to the algorithm refinement and validation of the system. All these existing systems are applied to dressed carcasses via standard rubbing rail systems. Work on these will continue during 07/08.

It is anticipated that in early 2007 that there will be two further commercial installations completed for beef and lamb processing:

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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.

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.

Project Outline

The following are the milestones:

Milestone and achievement criteria	
1	Shear force prediction & development of an industry bulletin and technical workshops to underpin launch of ALVS technology. Complete validation of tenderness and ultimate pH prediction from at least two smart stimulation commercial installations
2	Incorporate refined algorithms on the tenderness prediction in to the full US patent
3	Develop and validate a prototype system for measuring the response characteristics of hot boned muscles
4	Undertake a preliminary assessment using video image analysis of a carcass during electrical stimulation to identify the contractile characteristics of individual muscles
5	Using muscles of different fibre type characteristics, evaluate the ability of the contractile model to interpret the contractile characteristics and predict muscle structure
6	Compile an industry document on the measured benefits of G1 Smart Stimulation in existing commercial installations.
7	Complete installation, commissioning and calibration of Smart Stimulation at Hardwick's (Australian sheep plant) and ACC (Australian beef plant)
8	Provide an extensive report summarising work-to-date on the smart stimulation technology; include G1 and outline the details of the G2 option based on data generated in the above milestones.

Project Objectives

The objectives of the project are:

- Predicting tenderness
- Ultimate pH
- Installation and validation of at least 2 plants in Australia or 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, Results & Discussion

Refer to the supporting documents for detailed papers for each of the milestones (see Appendix):

Appendix A – Advanced Low Voltage Stimulation (Milestone 5 - Using muscles of different fibre type characteristics, evaluate the ability of the contractile model to interpret the contractile characteristics and predict muscle structure)

Appendix B – Advanced Low Voltage Stimulation (Milestones 7 - Complete installation, commissioning and calibration of Smart Stimulation at Hardwick's and ACC)

Appendix C – Advanced Low Voltage Stimulation (Milestones 8 - Provide an extensive report summarising work-to-date on the smart stimulation technology; include G1 and outline the details of the G2 option based on data generated in the above milestones)

Conclusion

The further development of the model described here provides a potentially useful measurement technique to described the functional and structural characteristics of a muscle. At this stage, a relatively simple stimulation protocol has been defined that appears to provide a means of describing fibre size (from the recruitment curve) and relative proportions of fast and slow fibres.

A review of the current status of the project is that currently 4 commercial installations (ie 2 beef, 2 lamb). These installations are being used to generate data that is critical to the algorithm refinement and validation of the system. All these existing systems are applied to dressed carcasses via standard rubbing rail systems. Work on these will continue during 07/08.

Recommendations / Commercial

Having now established what appears to an effective model system, the next step will be to undertake a process of modelling different stimulation conditions to identify protocols that will characterise muscle attributes quickly and with minimum ambiguity. The ability to predict distinctive muscle responses would help to confirm the validity of the model.

It is anticipated that in early 2007 that there will be two further commercial installations completed for:

- Beef – hide off, guts in stimulation applied on an individual carcass basis. The plant is hot boning and their interest is primarily in 1. the control of post-mortem pH decline and therefore reduction in meat quality variability and 2. identification of high pH carcasses before they reach the boning room.

- Lamb – A very high throughput lamb plant that will be used to test the ability of the system to run at high chain speeds. This system will also be used to validate the software and utilise the outcomes to refine meat quality and tailor it to specific customer requirements.

Acknowledgements

For each project, the relevant parties will contribute the intellectual property that they own, or are otherwise entitled to provide, that directly relates to the objectives and proposed outcomes of the Program. In particular M&WNZ agrees to procure and contribute the IP belonging to MIRINZ Inc that has arisen from the projects listed below.

At the date of this Agreement the parties intend to provide the Background IP arising from the projects listed below:

PSHIP.125	Advanced Low Voltage Stimulation (ALVS)
PSHIP.125B	Advanced Low Voltage Stimulation (ALVS)
PSHIP.125C	Advanced Low Voltage Stimulation (ALVS)

Resulting IP is shared between MLA and M&WNZ, on the condition that MIRINZ Inc will be acknowledged in any media release or public statement concerning the results of the MLA / M&WNZ collaborative research programme.

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. NMR studies were shared between MWNZ and MLA. The intellectual property is shared

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Appendix A - Advanced Low Voltage Stimulation (Milestone 5)

Refer to supporting documents P.PSH.0269 Advanced Low Voltage Stimulation (Milestone 5 - Using muscles of different fibre type characteristics, evaluate the ability of the contractile model to interpret the contractile characteristics and predict muscle structure)

Appendix B - Advanced Low Voltage Stimulation (Milestone 7)

Refer to supporting documents P.PSH.0269 Advanced Low Voltage Stimulation (Milestone 7 - Complete installation, commissioning and calibration of Smart Stimulation at Hardwick's and ACC)

Appendix C - Advanced Low Voltage Stimulation (Milestone 8)

Refer to supporting documents P.PSH.0269 Advanced Low Voltage Stimulation (Milestone 8 - Provide an extensive report summarising work-to-date on the smart stimulation technology; include G1 and outline the details of the G2 option based on data generated in the above milestones)