final report

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Application of ultrasound; cost benefit analysis

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Executive summary

Project A.TEC.0025 (PRTEC.025) complements PRTEC.003B. Its purpose was to determine the viability of a commercial intervention treatment system (ultrasonic or other) for vacuum-packaged meat by acquiring information on how the system might integrate with the current vacuum packaging process, the footprint required, and its capital and operating costs.

Industry consultation with beef companies in the MLA Top 25 indicated that there is processor interest in a system that treats vacuum packs after they are sealed, both to ensure absence of pathogens and to reduce the possibility of premature spoilage.
Both immersion and spray heat shrink systems are used by processors for shrinking the vacuum packs once they are sealed. There is a general preference for spray systems. The rate of passage of vacuum packs through shrink cabinets varies from plant to plant but is generally around 20 per minute.
In most boning rooms there would be very limited space for the intervention treatment equipment to be in series with the vacuum packaging and heat shrink equipment. Respondents felt that an intervention treatment that combined with the heat shrink treatment would best suit requirements. Two equipment suppliers are prepared to participate in a development project but are interested, firstly, in a system that complements spray shrink equipment.

Because preferences were expressed for a system that incorporates spray shrinking, two options were added to those considered:

- Sonotrodes in the spray unit; and
- Sonotrodes in a vessel immediately before or after the spray shrink unit.

There are likely problems with both options; the sprays may not be a sufficiently good coupling agent and for the option with the sonotrodes before or after the spray-shrink unit, the treatment may not be as effective as when the heat and sonication is applied concurrently. Unfortunately, microbiological performance data are just not available.

After a discussion with a potential commercialiser, Keam Holdem in New Zealand, MLA decided to explore the effectiveness of microwave treatment of vacuum packs. Food Science Australia was asked not to proceed with further investigations of ultrasound until we had collaborated with Keam Holdem to assess the effectiveness of microwave treatments. In February 2006, it was concluded that the microwave treatment could not be effective as a microbiological intervention without causing severe surface discolouration of the meat in vacuum packs.

This report outlines the further work on ultrasound that is necessary to give some indication of the likely technical success of the various possible configurations. Better information is required on how long the sonication treatment would need to be to be effective, particularly on whether sequential heat/sonication treatments are effective.

Once the necessary information is available, we propose that a decision be made with MLA about completing the detailed designs in collaboration with the packaging companies or other potential commercialisers.

Contents

1 Introduction

During 2003, Food Science Australia conducted preliminary investigations to determine if ultrasonics could be used to increase meat quality by reducing microorganism counts in final packaged meat. High power ultrasonics was studied for its ability to effect reductions in numbers of bacteria in intact vacuum packs. The Stage 1 project consisted of a series of investigations that was undertaken in a small system designed to treat small sealed sachets containing either broth cultures of *E. coli* or small pieces of fat tissue painted with the culture.

Sonication experiments using broth cultures of *E. coli* achieved reductions of 2.8 $\log_{10}$ *E. coli* cfu/mL in sachets held at 60°C for 30 s. Investigations using small sachets of vacuum-packed fat and lean tissue held at 75°C and sonicated for 15-30 seconds, showed microbial reductions of up to 3 logs, although reductions were not always consistent. Shorter treatment times could not be investigated because of OHS&E concerns with the way the prototype had to be used. Higher temperatures (>75°C) for shorter times (5-6 seconds) as used for heat shrinking may also be effective but in order to be able to investigate these conditions and verify that useful reductions in numbers of *E. coli* can be obtained, certain modifications would have to be made to the system configuration used in order to overcome the OHS&E concerns.

The study demonstrated that the lethal effect on microorganisms is a synergistic effect of temperature and ultrasound and is not due to heating alone. It identified a possible system design and treatment conditions for a pilot scale system for treating vacuum-packed meat primals. It was concluded that a scaled-up treatment vessel for larger packs must employ heat and sonication either simultaneously or in series. The preferred system for technical efficacy was full immersion of the vacuum packs in hot water to heat shrink the vacuum bags and simultaneously apply sonication.

The project report PRTEC.003B concluded that high power ultrasound is a processing technology that should be considered for applications in vacuum-packed and processed meat in that it offers an alternative to heat pasteurisation, high pressure, and irradiation for the treatment of intact packs of meat and other food products. A process using high power ultrasound has not been commercially developed for the treatment of meat products.

At the conclusion of the Stage 1 project PRTEC.003B it was determined by AMPC and MLA that the technology was worth progressing further. The next step - prior to any more trials being conducted to better understand the science and increase the microbial intervention efficiency (proposed Stage 3 project) – was to determine the potential limitations of a commercial system by working with the processing sector to understand where the technology is likely to be applied in the process, and to determine the approximate size of a commercial system and its capital and operating costs so that the anticipated cost per meat pack processed could be estimated.

AMPC and MLA envisaged that the outcome from the report of this commercial study would enable the industry to determine if further R&D into the science and efficacy of microbial inactivation, of this technology should be conducted as a Stage 3 project.

2 Project objective

To determine the viability of a commercial ultrasonic treatment system by gaining an understanding of how the system might integrate with the current vacuum packaging process, determining the footprint required, and estimating the capital and operating costs, enabling an indicative cost per meat pack processed to be determined.

3 Consultations

Discussions were held – either in person or by email and telephone – with staff representing the beef processing plants operated by the 25 top processors and with other existing or potential stakeholders. Sean Starling, MLA, participated in several of the interviews. The discussions did not emphasise ultrasound as the proposed intervention; rather they were in the context of any suitable technology that might become relevant.

4 Findings

4.1 Processors

1. There is processor interest in a system that treats vacuum packs after they are sealed, when recontamination with bacteria cannot occur.
2. The interest is to treat packs to both ensure absence of pathogens and to reduce the possibility of premature spoilage.
3. Both immersion and spray heat shrink systems are used by processors for shrinking the vacuum packs once they are sealed. There is a general preference for spray systems and spray systems are being progressively installed.
4. The rate of passage of vacuum packs through shrink tanks varies from plant to plant but is generally around 20 per minute.
5. Heat shrink treatment time varies from 2.5 to 6 seconds, commonly around 3-4 seconds.
6. It was felt that in most boning rooms there would likely be insufficient space for the intervention treatment equipment to be in series with the vacuum packaging and heat shrink equipment unless it was very compact.
7. Respondents felt that an intervention treatment that combined with the heat shrink treatment would best suit requirements.
8. As well as the space constraint, the technology would be unacceptable if it added to noise and worker discomfort.

4.2 Suppliers of vacuum-packaging equipment

1. Sealed Air Cryovac (Mr Robert Holzer) and Danaflex (Mr Gordon Little) expressed willingness to participate in a development project.

Discussions have not progressed beyond a preliminary stage however because it became apparent that before extensive system design work occurs, a microbiological investigation is needed to establish whether it is possible to combine ultrasound treatment with hot water sprays rather than water immersion and achieve useful reductions in numbers of pathogens and spoilage bacteria.

The comments about space limitation notwithstanding, there appears to be some evidence that cold water is a better coupling medium between the ultrasound sonotrodes and the vacuum packs. Therefore the comments above about limited available space should be reviewed with respondents once it has been established whether a combined spray shrink/sonication unit is technically feasible.

Preliminary drawings were prepared for a tank version where vacuum packs would pass through water to which ultrasound was applied. However, as stated above, several processors and the equipment suppliers expressed preference for a system that incorporated a spray shrink because spray shrinking is progressively replacing immersion because the incidence of heat-derived discolouration of such high-value cuts as tenderloins can be reduced. This led us to consider a procedure that involved spray shrink.

Two options were considered:

- Sonotrodes in the spray unit; and
- Sonotrodes in a vessel immediately before or after the spray shrink unit.

Drawings of some options considered are attached.

There are likely problems with both options; the sprays– as distinct from a full tank - of water may not be a sufficiently good coupling agent to transmit the sonic energy from the sonotrodes to the meat surfaces within the vacuum packs. For the option with the sonotrodes before or after the spray-shrink unit, as well as the additional space required, the treatment may not be as effective as when the heat and sonication is applied concurrently. Unfortunately, microbiological performance data are just not available yet to be able to recommend options worthy of further investigation.

5 Consideration of microwaves as an intervention

Enquiries have been made – via the scientific literature and potential system developers – to identify other intervention processes that might be alternatives to the hot water. Microwave treatment is a possibility if sufficient energy can be applied to the surface of primals without the meat surface being discoloured.

After a discussion with a potential commercialiser, Keam Holdem in New Zealand, MLA decided to explore the effectiveness of microwave treatment of vacuum packs. Food Science Australia was asked not to proceed with further investigations of ultrasound until we had collaborated with Keam Holdem to assess the effectiveness of microwave treatments. In February 2006, it was concluded that the microwave treatment could not be effective as a microbiological intervention without causing severe surface discolouration of the meat in vacuum packs.

6 Suggested way forward

We were asked by MLA to outline the further work on ultrasound that is necessary to give some indication of the likely technical success of the options and possible configurations.
To achieve a microbiological intervention solution for vacuum packs that is compatible with spray-shrink equipment, the sequential option – with the sonication unit immediately before or after the heat-shrink unit – is the one more likely to succeed technically. As this system will require additional space in the packaging line, it is important to know the necessary treatment time because this will determine the length of the unit, therefore its cost of installation and ultimately, its viability.

If the (spray) heat shrink treatment – duration 3 to 6 seconds generally in a cabinet around 2 metres long– has to be followed by a sonication treatment in cold water of, say, one minute or longer, the vessel and its conveyor – at up 12 to 15 times the length of the heat shrink cabinet – would probably be too long to be accommodated in any existing packaging room. If, on the other hand, it only needed to be the same length as the heat shrink cabinet, it may be acceptable in some existing packing rooms because cold water immersion or sprays are used in some establishments to impart some initial cooling of vacuum packs after they have been through the heat shrinking step.

It is recommended that funds be directed at obtaining the information on how long the sonication treatment would need to be for it to be effective. It is proposed that the initial trials be completed by 30 June 2006. The project funds not yet spent should be sufficient to cover this activity if the sequential heat/sonication treatments prove to be ineffective. If, however, the sequential treatments show promise, some additional trials should be carried out with packs of beef larger than those planned for the first trials. The additional trials would be an additional cost. They could be completed at an additional cost of $23,500.

We propose that a decision then be made with MLA about completing the detailed designs in collaboration with the packaging companies or other potential commercialisers. This activity, and the preparation of the required detailed report, would cost around $28,000. We are therefore asking that up to $58,000 in funds - in addition to the $25,089 in funds not spent in this project - be provided for the investigation.

7 Diagrams

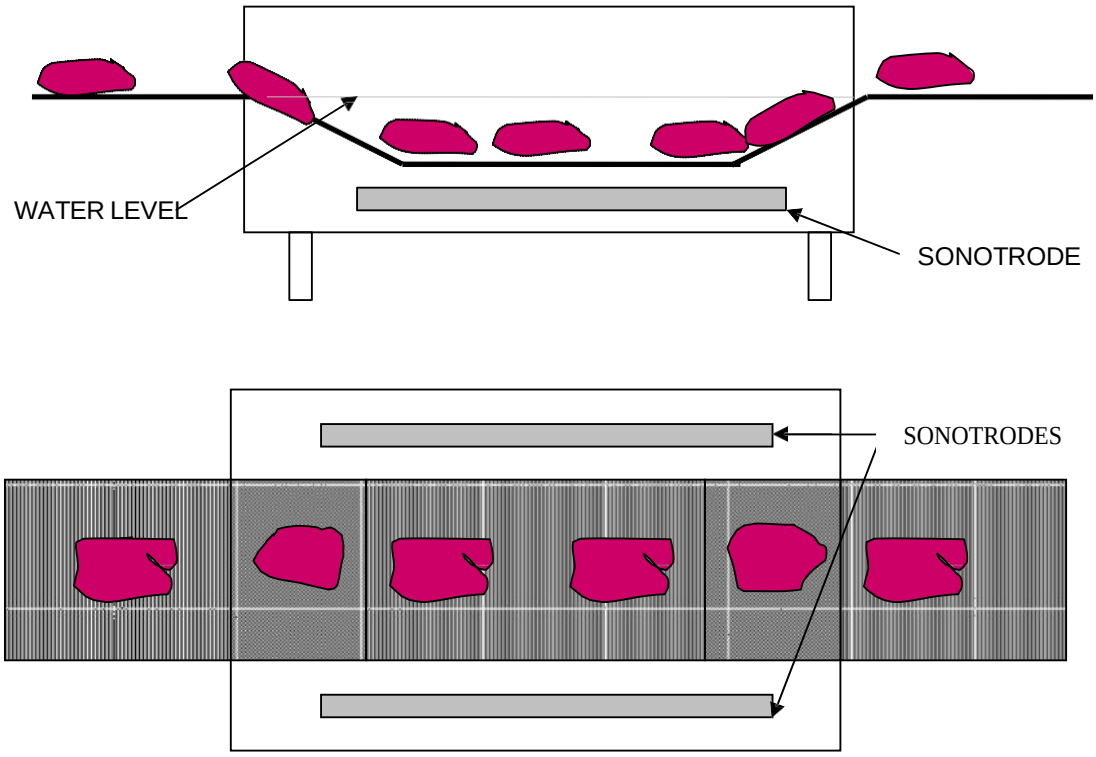

Figure 1. Envisaged combined hot water immersion shrink and sonication

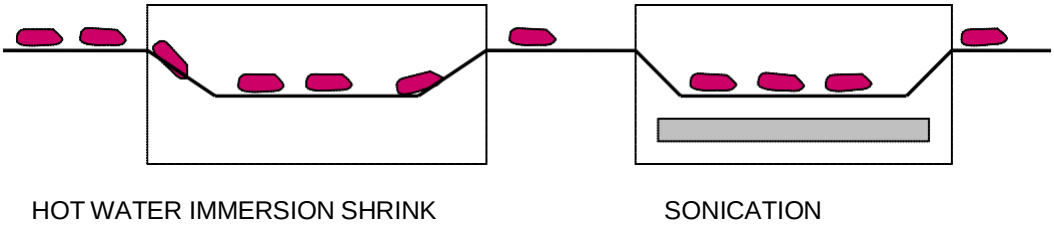

Figure 2. Sequential hot water immersion shrink and sonication in water (hot or cold)

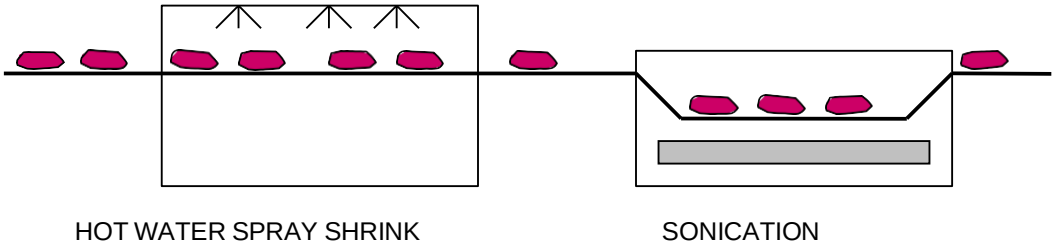

Figure 3. Sequential hot water spray shrink and sonication in water (hot or cold)

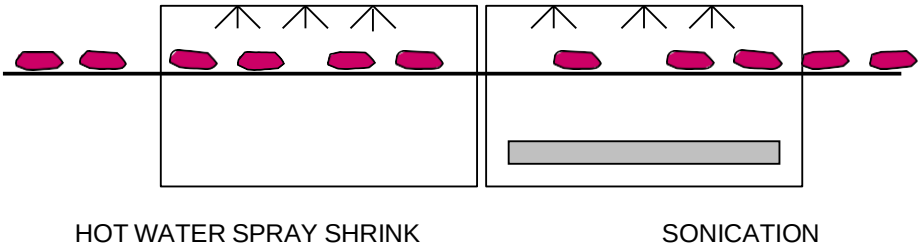

Figure 4. Schematic of possible sequential hot water spray shrink and sonication treatment system employing water sprays (hot or cold) as coupling agent

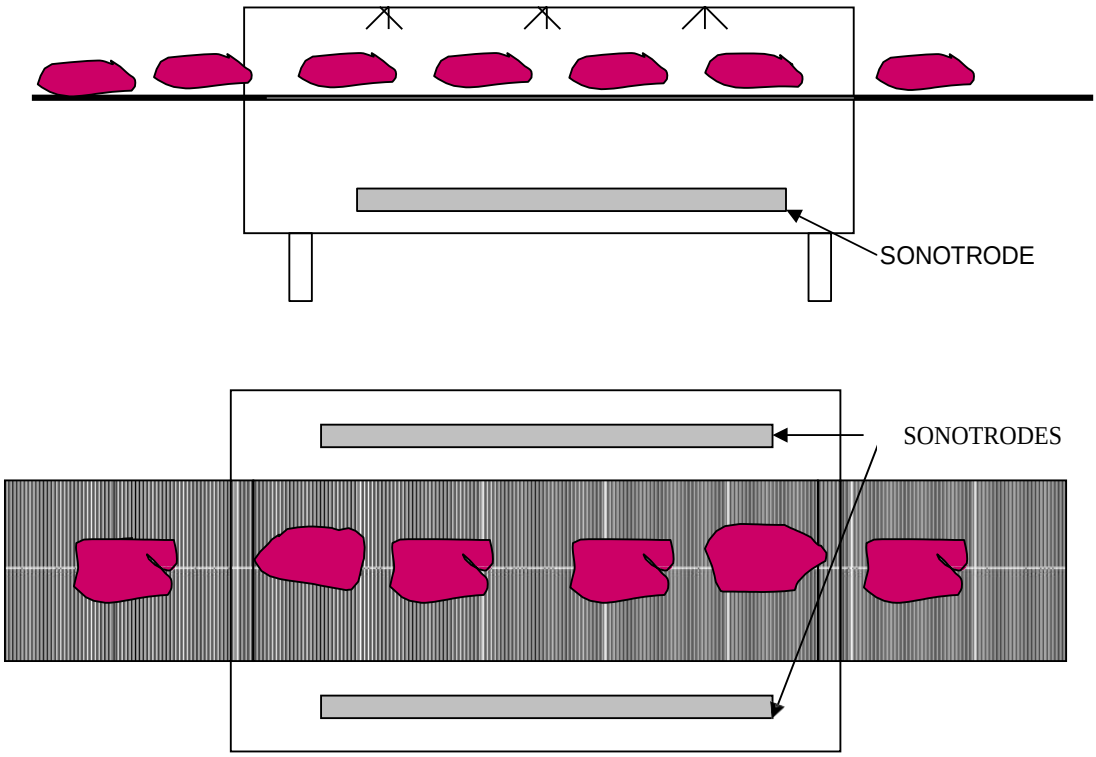

Figure 5. Schematic of most convenient system – simultaneous hot water shrink employing the spray as the sonication coupling agent