Results for today; Ideas for tomorrow

Meat Technology Update

Newsletter 3/04 June 2004

Slaughter floor electrical inputs for beef carcases

The term 'electrical input' refers to all currents applied to the carcase on the slaughter floor, and includes those applied for the following reasons:

- immobilisation of carcases following stunning;
- additional blood release following sticking;
- carcase rigidity at the downward hide puller; and
- prevention of meat toughness (electrical stimulation).

In addition to their intended physical effect on the carcase, each of these electrical inputs may contribute to the pH decline in the muscles. Excessive electrical inputs may effectively over-stimulate carcases and cause a rapid pH decline with undesirable effects on meat-eating quality. Thus, when evaluating the overall effect of an electrical input, it must be considered in conjunction with all other electrical inputs being applied to the carcase.

Figure 1. Downward hide puller

Electrical inputs

Electro-immobilisation

Animals kicking following stunning is a substantial safety hazard for beef-plant processing personnel. Even with effective stunning there may be unpredictable, vigorous movements of the hind legs. These can lead to falls and bruising amongst employees as well as accidents with the sticking knife or shackle chain. The movements may occasionally occur several minutes after stunning and sticking and thus place at risk those employees involved in operations further along the processing chain, for example, at the 'first-legging' station.

Electrical currents can be applied via electrodes on the cradle which supports the carcases after they have been released from the knocking box, to consistently immobilise them: electro-immobilisation. Because of the range of animal sizes and the range of positions in which bodies land on the cradle, care needs to be taken to ensure that each receives the required current. In general, the electrodes should be designed to have a large surface area and occupy as much of the cradle as is practically possible. Hosing the cradle after each body will assist in maintaining optimal electrical contact.

Modern electro-immobilisation systems incorporate medium voltage, high frequency waveforms which provide a still carcase

AMPC
MEAT & LIVESTOCK AUSTRALIA
FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AFISC
CSIRO
Afisc Australian Food Industry Science Centre

Electrical inputs and the MSA muscle pH/temperature window

For optimum meat-eating quality, it is necessary to ensure that neither cold-induced toughness nor heat-induced toughness occurs. For this reason it is suggested that when the loin muscle reaches a pH of 6, the temperature of that muscle should be above 12°C but below 35°C.

For example, if the muscle pH value is 6 and the temperature is 36°C, then the body does not lie within the window and is said to be 'outside the hot end of the window'. If the loin commonly reaches pH 6 at a temperature above 35°C, then it will be necessary to consider ways of reducing the electrical inputs. To minimise the risk of this high temperature/low pH condition, it is desirable to routinely 'run off' bodies into chillers before workers leave the slaughter floor for breaks.

In any abattoir with more than one electrical input, it is unlikely that the temperature at pH 6 would be below 12°C. Because of the common use of electrical inputs on beef-processing chains, cold-induced toughness is no longer a major cause of poor meat quality; however, the possibility of cold-induced toughness must always be considered when planning hot-boning operations.

The temperature at pH 6 can be calculated from 2 sets of pH/temperature measurements: one with a pH value of above 6; and one with a pH value below 6. These values can be entered into an Excel spreadsheet and the temperature at pH 6 calculated. Because there is considerable individual variation, the temperature at pH 6 should be determined by taking the average for a group of around 15 bodies, rather than just one individual body.

after the current is switched off. This enables shackling to take place while the hind legs are relaxed. The current may need to be applied for a period of 7 to 10 seconds before this state of relaxation is produced. Unfortunately this presents problems in high throughput plants where it will probably be necessary for the shackler to apply the shackle while the current is being applied. If bodies land poorly on the cradle or move, there may be irregular contact with the electrodes. For this reason, shackling while current is being applied is not the preferred method of using electro-immobilisation systems.

Where a problem of kicking at the first-legging station exists, and which cannot be cured by post-stunning immobilisation, then it may be necessary to install a second electro-immobilisation unit. In this case, the application of current could be via rubbing bars similar to those described below.

Bleed rail stimulation

When cattle are processed to meet the Halal religious requirements, the initial bleeding incision is a transverse incision across the neck. This will usually be followed by a lengthwise incision to sever the major vessels in the vicinity of the heart (a 'thoracic stick'). For cattle not being processed to meet Halal requirements, the only bleeding incision will be the thoracic stick. In the 1 or 2 minutes following a thoracic stick there is a major release of blood, but minor amounts are still being released as the carcase progresses along the slaughter chain. It is highly desirable to maximise the amount of blood released quickly, as this blood is collected via the blood drain and eventually processed and sold. The blood that is released onto the slaughter floor, away from the blood drain, will be hosed to waste where it will create a biological load on the effluent treatment system.

It has been demonstrated that the application of a low frequency electric current to the carcase soon after the thoracic stick will lead to an increase in the amount of blood released into the blood drain and a decrease in the amount of blood present on the slaughter floor. Using medium voltage, low frequency waveforms, the amount of extra blood released into the blood drain is of the order of 1 kg per carcase and, in some cases, up to 1.5 kg per carcase. As might be expected, the more effective the system is in releasing additional blood, the more rapid the pH decline and the greater the temperature at pH 6 (see box above for a discussion of the MSA [Meat Standards Australia] window).

The current can be applied to the hide-on carcase via rubbing bars at the top (hind leg) and bottom (shoulder region) of the carcase. The duration of current application can be of the order of 30 seconds.

To achieve the release of a significant amount of extra blood, it will be necessary to apply the electric current shortly after the thoracic stick; however, electric currents applied to the carcase or the side at any stage along the slaughter floor may lead to the release of small quantities of additional blood. This would be of no direct economic significance; but, if it could be collected into a secondary blood drain, it may help reduce the BOD of the slaughter-floor effluent.

Hide-puller stiffening probes

The application of current at the downward hide puller is necessary to induce rigidity in the carcase while the hide is pulled over the head and shoulder of the carcase. If current is not applied, there is likely to be an unacceptably high incidence and severity of broken backs. Although the duration of application of the current is generally short (7–15 seconds), when applied in conjunction with other electrical inputs, it can contribute to a decline in muscle pH that is outside the MSA window.

The waveforms incorporated into modern hide-puller electronic units minimise the effect on pH decline, but it may still be advisable to minimise the duration of application of the current. It is probably only necessary for the current to be applied while the hide is actually being pulled over the head. The training of operators—including those involved in some of the work-up operations prior to the hide puller, e.g. horn removal, hock skinning—can reduce the time required for the application of current. If rapid pH decline is a continuing problem, then

replacement of the electrical system with a mechanical system is a possibility. The sternum hook has been shown to be practical and cost-effective in smaller works. This is a simple device that supports the carcase through the sternum to reduce the load on the spinal column during downward hide pulling, and reduces the incidence of broken backs. (Refer to MLA Do-It-Yourself Kit #16.)

Electrical stimulation (ES)

It is well documented that beef carcases that cool rapidly may have poor meat quality as a result of cold-induced shortening and toughening. The Tenderstretch process prevents the shortening of many muscles of the carcase and thus produces meat of superior eating quality. Where there is a preference for the conventional Achilles-tendon hung—rather than the Tenderstretch hung—beef side, it may be necessary to apply an electrical current specifically to prevent cold-induced toughness. This process is referred to as 'electrical stimulation' (ES) and, for many years, was often the only electrical input (other than hide-puller stiffening) applied to the carcase.

ES is used less commonly now as the combined slaughter-floor electrical inputs generally provide adequate stimulation. If ES is required, it can be easily applied to the beef sides via rubbing bars, prior to their entry into the chiller. Medium voltage systems using a 14 Hz waveform are available for this application.

For low throughput beef-processing plants, with few other electrical inputs, there may still be a role for the ES to be applied to the body after stunning and sticking via manually inserted nostril and rectal probes.

Controlling cumulative electrical inputs

It is now acknowledged that 'over-stimulation' is possible and the combination of ES with other electrical inputs can have deleterious effects on meat quality. Excessive electrical inputs lead to a rapid fall in muscle pH. This occurs particularly with carcases from good quality long-fed feedlot cattle. In some cases a muscle pH of 6 may be reached before the carcases enter the chiller. This means that, regardless of the efficiency of the chiller, rigor (muscle pH < 6) is achieved at a high temperature. This in turn causes heat toughening which may mean a decrease in overall acceptability of the product by consumers. Furthermore, with heat-toughened muscles, there is little improvement in eating quality with ageing.

The risk of over-stimulation can be minimised by anticipating the cumulative total of all electrical inputs each carcase type receives, and regulating the amount of electrical stimulation (and sometimes the immobilisation and back stiffening) to give an optimum overall effect.

Recent work has focused on ways to lessen the amount of electrical energy input required to achieve effective carcase immobilising and back stiffening, and to provide better control over these functions. By reducing the amount of electrical energy input during these early operations, there is more scope for the application of controlled amounts of beneficial electrical stimulation without the risk of over-stimulating the carcase.

Presently, adjusting the various sources of electrical inputs—immobilising, bleeding, back stiffening and stimulation—in an effort to ensure that each animal receives an optimum total input, is a manual process. Different optimum levels apply, depending on the types of animals to be slaughtered. Typically, feedlot cattle require a lower level of total input than grass-fed cattle.

A new management system, the Computer Process Management System (CPMS) jointly developed by MLA and Applied Sorting Technologies, can provide the means to store, in memory, the optimum electrical parameters of all the electrical inputs for each carcase type processed, and to sequentially change the parameters of each electrical input as a particular carcase type arrives at that station.

Other considerations

Ultimate pH

Electrical inputs accelerate the rate of pH decline and, therefore, will reduce the time for the ultimate pH to be reached. Carcases that receive no electrical inputs and are chilled rapidly may take 24 or even 48 hours for the ultimate pH to be achieved; however, in commercial practice, most carcases will be at, or very close to, their ultimate pH by 18 hours. Chiller assessment cannot be undertaken until the loin muscle has reached its ultimate pH.

Carcases that have received several electrical inputs may reach their ultimate pH within a few hours of slaughter and, thus, can be assessed at an earlier time than would otherwise be permissible.

Meat colour

Until the ultimate pH is reached, the muscles of carcases that have received electrical inputs are likely to be lighter in colour and have a brighter red colour than those from similar carcases that have not received electrical inputs. Electrical inputs are likely to have a comparatively minor effect on the colour once the ultimate pH is reached, but over-stimulation may cause a paleness of the muscles. In extreme cases this may be similar to the condition of pale soft exudative (PSE) muscles seen in pork carcases.

Safety

The safety aspects of electrical inputs used in the wet environment of a meat-processing works must be taken into account. Early low voltage electrical stimulation (LVES) systems were designed for there to be low risk of cardiac arrest as defined in the Australian Standard AS/NZS 60479 (Effects of current on human beings and livestock) as they were used in the bleeding area of works where workers could come in contact with the stimulated carcases. The early designs used a relatively low peak voltage to satisfy the standard and this limited the stimulation current that could be applied.

Recent research has shown that electrical waveforms with much narrower pulses are still effective and this has enabled much higher peak voltages to be used safely. The safety calculations stipulated in the Australian Standard uses an effective RMS voltage when calculating safety and, as the pulse width is reduced, the RMS voltage drops. This allows larger peak voltages to be used safely while the RMS voltage is kept low due to the narrow pulse.

High voltage electrical stimulation (HVES) applied at the end of the slaughtering process used high, dangerous voltages, as these voltages were necessary at this stage in the process to stimulate muscle directly (the nerves which the low voltage systems worked on had now died). Elaborate and expensive safety enclosures were necessary to keep workers away from the stimulated carcases and many plants found it hard to find room for these systems.

The electrical techniques used for the new LVES can also be applied at this stage of the process, and a new technique termed mid-voltage electrical stimulation (MVES)—using very narrow pulses—can now replace the HVES with a relatively safe system. These systems do not need the elaborate safety enclosures and are much easier and cheaper to install.

As mentioned earlier, electrical inputs at bleeding and the immobilisation, also use the safe, narrow pulses described above; making it possible to have people work on, or near, the carcase while these energies are applied.

Electronic hide-puller back stiffeners are also available using the narrow pulse technique and, although these systems are not totally safe, they are much safer than the mains-frequency back stiffeners which have been used for many years.

Further Reading

Meat & Livestock Australia Technology Transfer Resource Package #2: DIY # 16: Beef Sternum Hook. Stock Code PP1217. This MLA kit is in brochure form and comes with an instructional video. It is also available as a stand-alone CD-ROM.

Thompson, J. (2002). Managing Meat Tenderness. Meat Science 62: 295-308.

Additional information available on web sites

www.meatupdate.csiro.au – Information sheet: High rigor temperature and toughening in beef.

www.mla.com.au – Tips and tools and facts sheets/MSA and SMEQ: The effect of the pH temperature decline on beef eating quality.

Abattoir equipment

The following equipment, suitable for incorporating into a Computer Process Management System, is available:

- High frequency, mid-voltage, CPMS immobilisation;
- Low frequency, mid-voltage CPMS bleed rail stimulation;
- CPMS back stiffeners;
- Mid-voltage CPMS electrical stimulation.

For further information on this equipment contact:

Paul Keane at Realcold Milmech Pty Ltd.
Telephone (07) 3340 1100
Fax (07) 3340 1122
Mobile 0407 882 326
Email: pkeane@realcoldmilmech.com.au

For more information, contact one of the Meat Industry Services staff listed below.

Food Science Australia Meat Industry Services Section

The Meat Industry Services (MIS) section of Food Science Australia is an initiative supported by Meat and Livestock Australia (MLA) and the Australian Meat Processor Corporation (AMPC) to facilitate market access for, and support world-class practices in, Australia's meat industry.

Need additional help, information or advice? *Contact one of the following:*

BRISBANE:
Food Science Australia
PO Box 3312
TINGALPA DC Qld 4173

Ian Eustace
Ph. 07 3214 2117
Fax. 07 3214 2103
Mob. 0414 336 724

Neil McPhail
Ph. 07 3214 2119
Fax. 07 3214 2103
Mob. 0414 336 907

Donna Knox
Ph. 07 3214 2109
Fax. 07 3214 2103
Mob. 0416 198 402

SYDNEY:
Food Science Australia
PO Box 181
KURMOND NSW 2757

Bill Spooncer
Ph. 02 4567 7952
Fax. 02 4567 8952
Mob. 0414 648 387

MELBOURNE:
Food Science Australia
Private Bag 16
WERRIBEE Vic. 3030

Jocelyn Midgley
Ph. 03 9731 3424
Fax. 03 9731 3250
Mob. 0414 647 231

ADELAIDE:
PO Box 178
FLAGSTAFF HILL
SA 5159

Chris Sentance
Ph. 08 8370 7466
Fax. 08 8370 7566
Mob. 0419 944 022

Additional copies of this newsletter are available from: www.meatupdate.csiro.au