final report

Project code: P.PIP.0143

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Date submitted: June 2008

PUBLISHED BY
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Innovative stock washing system to control cattle cleanliness

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 and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Executive Summary

The provision of clean cattle for slaughter is generally considered an essential prerequisite to protecting the food chain from microbial contamination. The Klenzion Stock Washing system involves application of a detergent cleanser to cattle immediately prior to ante-mortem inspection using a purpose-built spray system. Use of this cleaning system is reported to assist in removal of gross hide contamination. If effective, the Klenzion Stock Washing system offers a variety of benefits, including:

- Reduced carcase hygiene trimming resulting in reduced trimming costs, improved carcase yield and less carcase downgrading
- Reduced pre-slaughter stress, which is linked to dark cutting meat that results in carcase downgrading and reduced returns.
- Reduced number of production stops or slow-downs, particularly in winter and wet periods.
- Reduced water consumption during livestock washing
- Incorporation into the processor's HACCP quality assurance programme and risk management plan.
- More effective compliance with the Australian Standard for hygienic production and transport of meat and meat products for human consumption.

In order to test the effectiveness of the Klenzion Stock Washing system on cattle under commercial operating conditions, it was trialled at a high volume beef slaughter facility in SE Queensland. Project Objectives were:

1. To evaluate the ability of the Klenzion washing system to reduce visible contamination loads on cattle surfaces prior to slaughter.
2. To determine application strategies for cattle in different conditions
3. To evaluate the benefits of using the Klenzion washing system
4. To evaluate the cost per head of undertaking the selected treatment techniques
5. To produce a report on the findings of the trial

Field trials were conducted to concurrently compare washing efficiency of the Klenzion system to the currently used water spray system, acting as a control. Initial set up procedures and preliminary trials were conducted to demonstrate in-concept efficacy and practical useability of the system, and optimise data collection methods. A full-scale trial was then commenced. Assessment of efficacy of the wash system was based on reductions in times required to manually hose mobs of cattle to an acceptable cleanliness level for slaughter. Savings in water use were calculated from these time differences. In order to address objective 2, it was applied to cattle that varied in their degrees of cleanliness. The degree of hide soiling was rated using a standardised visual cleanliness assessment scheme. Effectiveness of the Klenzion system was to be correlated to the degree of hide soiling of incoming cattle. Meat Hygiene Assessment data was collected, primarily to investigate associations between initial soiling levels and levels of carcase contamination using a cleanliness-intervention matrix. Blinding and randomisation were incorporated into the experimental design.

A total of 16 mobs, incorporating 948 cattle, were used within the trial. This was considerably less than was originally proposed, as the project was terminated early. Use of the Klenzion wash system resulted in significant reductions in both the time taken and water volume required to get cattle acceptably clean for slaughter. This difference was not significant enough from a commercial perspective to justify use of the product, based on water and labour costs for the specific plant in which trials were conducted. Meat Hygiene Assessment data was not sufficient to adequately assess the effects of initial hide soiling levels or the effects of Klenzion application. Testing of the Klenzion system across a range of cattle cleanliness levels could not be fully

achieved, as drought conditions in the areas from which cattle were sourced meant that very few mobs or individual cattle had soiling scores beyond light (score 3.5 or below). Thus, data over the full range of scores necessary to complete a cleanliness versus intervention matrix (i.e. objective 2: explore application strategies for cattle in different conditions) could not be collected.

Major conclusions are summarised as:

1. Issues relating to heavily dagged cattle being presented for slaughter continue to be a problem for beef processors.
2. Following analysis of current trials, the participating plant has decided not to proceed with a commercial installation of the Klenzion system at the site. The reasons for this are outlined in this report. These can be summarised as:
   a) on the basis of the time saved in cattle washing in the trial, this would not extrapolate to labour savings at the site
   b) while water savings were recorded these did not alone justify commercial installation of the system (in this regard it is noted that for cattle destined to all markets other than the European Union the majority of cattle washing is currently undertaken using tertiary recycled water)
   c) the application as installed did not adequately address heavily tagged animals. In this regard it is acknowledged that Klenzion does not claim that its current product is suitable to treat heavily contaminated feedlot cattle. However, grain-fed cattle represent a substantial proportion of intake at the trial site.
3. A significant inhibiting issue in executing this project was the lack of an objective assessment system which determined the level of stock cleanliness that was commonly understood by AQIS and industry. Furthermore, should such a system ever be agreed, interventions such as the Klenzion system may make a valuable addition to the food safety/ quality assurance controls implemented by meat processors, in that they may assist in achieving objective measures which determine acceptability for slaughter.

From these conclusions, future recommendations are:

1. Trialling products and/or protocols that minimise dag accumulation at the farm level.
2. Devising and trialling interventions other than washing at the processing level to mitigate hazards associated with particularly heavily dagged cattle, e.g. increased carcase inspection and/or trimming, logistic processing.
3. Developing a more objective and auditable cattle cleanliness assessment system that can be integrated into existing quality assurance programs such that future interventions can be targeted to the higher risk cattle and be more effectively monitored.

Major benefits to the beef industry from this project include:

1. Determination of practical and commercial considerations relating to use of proprietary cattle wash systems for improving the hide cleanliness of cattle for slaughter.
2. Identification that priority should be given to the development of an objective scoring system which determines the suitability of cattle for slaughter which is agreed by AQIS and industry. This could be undertaken in a commercial setting, thus determining its proof-of-concept useability for future projects and in general.

Contents

1 Background

1.1 The Need for Livestock Cleanliness

The provision of clean, healthy cattle at slaughter is essential to maximising the safety and quality of beef production. Livestock are exposed to and may be colonised by a variety of microorganisms prior to slaughter. Some of these are considered a hazard to the safety of meat products and therefore to the consumer of these products. Contamination of carcasses with pathogenic organisms generally occurs via faeces, hair, hides and hooves and water *(2, 3, 5)*. Prevention of contamination by these mechanisms is essential to produce a safe product with an adequate shelf life to maintain the industry's export markets.

An important factor in the supply of safe meat is the condition of stock supplied for slaughter. In theory, the dirtier the condition of the stock at slaughter, the greater is the potential for microbiological contamination of the carcase. This association has not always been borne out in the scientific literature, although much of this is because of a lack of consensus on how to grade the degree of hide contamination. However, intuitively and as an industry standard, cattle presented for slaughter are expected to conform to a minimum standard with respect to hide cleanliness. The supply of clean stock (free from dirt, dust, dags and other physical contaminants and with a lowered microbial surface load) is an important critical control point in reducing or minimising the microbiological contamination of the carcass, thus increasing the safety of the subsequent meat product/s. Although Australian cattle are usually relatively clean when presented to the abattoir, there is a large degree of variation. Much of this relates to factors such as cattle breed; distance travelled to the abattoir; climatic conditions (particularly rainfall) immediately prior to slaughter; and management factors such as stocking density.

Legislation / Standards
Australian Standard for hygienic production and transport of meat and meat products for human consumption *(1)* describes cleanliness of animals before slaughter under section 8.4 and 8.5:
8.4 Reasonable steps are taken to present animals for inspection in a clean condition.
8.5 Animals that are not clean are not passed for slaughter or are passed for slaughter subject to conditions that ensure they do not contaminate animal, carcases and carcase parts during slaughter, dressing, post-mortem inspection and disposition.

Antemortem Procedures and Preventative Actions.
Cattle are checked for cleanliness on antemortem inspection by both abattoir personnel and Australian Quarantine Inspection Service (AQIS) on-plant veterinarians (OPVs). Any stock that are visibly filthy, particularly with caked-on dag, must be cleaned until passed as acceptable for slaughter by the OPVs. This creates significant economic burdens on the abattoirs due to labour costs and reduced throughputs. Water use associated with cleaning is also an issue, and one that has been magnified by the drought. It also creates a welfare concern, in that excessive handling of cattle and use of techniques such as high-pressure hosing can have negative impacts on stock. This in turn has economic consequences, as excessive stress and bruising can lead to quality downgrading of beef. Extensive hand washing may only be an option in warmer climates, yet dirtier cattle are often more prevalent in temperate areas with higher rainfall. Further problems are thought to exist in that even though cattle appear to be clean on visible inspection, heavily dagged cattle (which can never be totally cleaned) remain contamination threats to the food chain once dressed and processed.

The problem of dirty cattle at slaughter has historically fallen on the abattoir. A regularly identified issue is that there is currently no method of objectively grading the cleanliness of cattle using a standardised, validated, auditable system. Such a system would allow agreement between

industry personnel and AQIS inspectors as to what constitutes an unacceptable animal on the basis of hide soiling, and provide an improved basis for protocols that mitigate risk or at least identify problem areas at the ante mortem level. It would also allow abattoirs to provide sound feedback to producers on the quality of stock being provided with respect to hide contamination, and would share the responsibility of maintenance of cattle cleanliness back up the production chain; i.e. during transport, at saleyards, and on the farm.

1.2 Livestock Washing

Live animal washing is normally sited so that cattle move from unloading into receiving pens and pass through a spray wash pens (non-potable) followed by a potable wash immediately prior to slaughter. The purpose is to wash contamination (dirt/faeces/hair/etc) to reduce surface contamination loads. A common practice is use of an automated spray wash followed by hand held hosing to remove residual material.

Klenzion
The Klenzion system is designed to take advantage of and extend the benefits of live animal detergent wash systems.

The current system being used by Klenzion to achieve “visually clean” stock is as follows:

- Animals are passed through an applicator that applies a proprietary cleaning product.
- They are then placed in a pen where the minimum dwell time is 10 minutes, where the cleaning product loosens dirt and dags.
- Cattle are passed through the plant’s existing wash system that rinses the hide free of dirt and contamination.

Some beef processors are reputed to be using up to 1,000 litres of water per head for washing cattle. Klenzion’s target is 60 litres per head if an appropriate rinse-off system is used. A rinse-off system was not installed as part of the current trial, therefore this claim was not formally assessed. The Klenzion wash system is designed for use on grass-fed cattle, and does not claim specific efficacy against grain-fed or lot-fed cattle, where the nature of hide soiling is considerably different to that of grass-fed cattle.

Development and introduction of uniform cattle cleanliness standards would benefit the industry by providing transferable and clearly defined goals for producers, purchasers, slaughterers, regulators and inspectors. There is similarly a demand for products and/or protocols that can improve the efficiency of stock cleaning. Such developments will benefit the beef industry with respect to economic efficiency, food safety (and therefore human health protection, and product security and marketability), environmental protection (through reduced water consumption and waste) and animal welfare. This offers substantial benefits, considering the importance of beef production to the Australian and Queensland economies and ways of life.

1.3 Potential Industry Benefits

The potential benefits of the Klenzion Stock Washing system include:

- Reduced carcase hygiene trimming resulting in reduced trimming costs, improved carcase yield and less carcase downgrading

- Reduced pre-slaughter stress, which is linked to dark cutting meat that results in carcase downgrading and reduced returns.
- Reduced number of production stops or slow-downs, particularly in winter and wet periods.
- Reduced microbial loads on the carcase surface
- Reduced water consumption during livestock washing
- This system can be incorporated as part of the processor's HACCP quality assurance programme and risk management plan.
- Environmentally friendly as products are biodegradable.

2 Project Aims and Objectives

The overall aim of the project is to assess the efficacy and commercial feasibility of use of the Klenzion washing system on Australian cattle at slaughter within a typical industry context.

Project Objectives:

1. To evaluate the ability of the Klenzion washing system to reduce visible contamination loads on cattle surfaces prior to slaughter.
2. To determine application strategies for cattle in different conditions
3. To evaluate the benefits of using the Klenzion washing system
4. To evaluate the cost per head of undertaking the selected treatment techniques
5. To produce a report on the findings of the trial

3 Methodology

3.1 Overall Approach and Milestones

Trials were conducted at a high volume (>1400 head/day) beef processing plant located in southeast Queensland. Experimental design was that of a series of field trials to concurrently compare washing efficiency of the Klenzion system to the currently used water spray system, acting as a control. Blinding and randomisation were incorporated into the experimental design (see Technical Materials and Methods section). All experimental procedures were conducted in accordance with the Queensland Animal Care and Protection Act 2001, under the Animal Ethics Approval number CA2007/06/200. The facility at which the trials were conducted was registered (Number 289) with the Queensland Department of Primary Industries and Fisheries for use of animals for a scientific purpose.

The project was staged over a series of milestones, such that in-concept efficacy and practical use under commercial conditions could be assessed before progressing to more extensive trials. The initial milestone stages also allowed for further development of methods and acquisition of preliminary data for use in optimising final trial design. Milestones and associated objectives and activities (as described below) collectively addressed overall project objectives.

Milestones

Milestone		Key Objectives and Activities
1	Scoping visit	a. Meeting of key personnel, basic project design. b. Scoping of site to determine the logistics of equipment installation and interaction with existing infrastructure and operations. c. Costing of procedures and project budget modification (if required). d. Resultant 'go/no go' decision made between all parties.
2	Project setup	a. Set up and convene the project steering group. b. Install and test the Klenzion wash system on site. c. Verify the wash system is working as specified by Klenzion. d. Train respective personnel in using the prescribed cattle cleanliness scoring system. e. Perform commercial-level mini-trials of the wash system to optimise methods for Milestones 3 and 4. f. Make a second consensus 'go/no go' decision on the basis of the above points. g. Apply for animal ethics and other necessary approvals.
3	Major trial	a. Perform the concurrent treatment (Klenzion) and control (standard water) wash procedures on mobs of cattle over (nominally) 6 months or for 50000 head of cattle. b. Collate, audit and analyse data.
4	Develop an auditable cleanliness assessment system	a. Use data from Milestone 3 to prepare a matrix of cattle cleanliness vs. cleaning intervention. b. Optimise a system of assessing the degree of cleanliness of cattle based on the system used for Milestone 3. The system should use a criterion-based system of assigning scores to lots of cattle that are at least semi-objective, justifiable and auditable. It should also be robust across a range of cleanliness scores, operating conditions, operators. c. Consider operational procedures that can use the cleanliness rating system and interventions matrix to minimise hazards associated with dirty cattle.
5	Final report	Collation of all activities, data and results for dissemination to industry via MLA.

Project Timeline

Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr - Aug 07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
Scoping	Setup					Preliminary trials			Trials						Project finalised	

3.2 Technical Materials and Methods

3.2.1 Experimental Protocol

The following protocol was provided to all participants in the trial. It aimed to standardise conduction of data collection across each trial.

1. Selection of experimental lots
    a. Performed by David Summerville.
    b. Select three lots of 40-50 cattle per day.

c. Only select from lots available within daylight hours.
d. Select one lot each to represent light, medium and heavy soiling, within the bounds of all lots available. Within these broad categories, select lots randomly.

2. Dag scoring and treatment allocation
    a. Performed by David Summerville.
    b. For each of the three lots selected, score the degree of dirtiness for the leg, side and belly for seven individual cattle and record on the Dag Score Sheets.
    c. Ensure the same animal is not scored twice by paint gun identification of scored cattle.
    d. Divide the lot into two split lots ("splits") of approximately equal cattle numbers (20-25).
    e. Identify each split such that they can be tracked as group through slaughter.
    f. Using a coin toss, allocate splits from each lot randomly to Treatment (heads) or Control (tails) and record split ID and treatment allocation on the Dag Score Sheets.

3. Application of treatment
    a. Run treatment cattle through the Klenzion applicator and into an ante-mortem pen.
    b. Run control cattle directly into an ante-mortem pen, and apply pen sprays for 10 minutes.
    c. Note the dwell time for both Treatment and Control splits (i.e. time of soaking of Klenzion or spray water following application) on the Wash Data Sheet by stopwatch. Aim for both Treatment and Control groups to have 15-20 min dwell time. Ensure consistency in dwell times across splits, lots and days as much as possible.

4. Cattle washing
    a. Washer:
        i. Wait for Recorder's go-ahead.
        ii. Apply high-pressure hosing to each animal in the split until they are fit for slaughter, as assessed by the Washer.
        iii. Continue to next split, with Recorder's go-ahead.
    b. Recorder (David Summerville):
        i. Ensure the Washer is blinded as to Treatment and Control allocation.
        ii. Record the time taken to hose each split to acceptable cleanliness – i.e. from the time the hose first hits an animal to the time it is no longer directed at an animal.

5. Collection of production data
    a. Performed/supervised by Alan Platten, blinded as to treatment or control identification.
    b. Proceed each split (irrespective of whether Treatment or Control) to slaughter and processing in the standard commercial manner.
    c. For each split, record/transcribe the following:
    d. Meat Hygiene Assessment (MHA)
        i. Performed after final trim and before final wash.
        ii. Scoring performed as described in the AQIS MHA Manual.
        iii. Record data for five samples per split, i.e. as per AQIS MHA Manual "Normal" or "Reduced" rates for lot sizes of ≤25.
        iv. Record raw scores for carcasses/sides corresponding to each split using the Carcase Product Monitoring Sheet.
    e. Dark cutters
        i. Performed as part of the routine chiller assessment procedure.
        ii. Record individual meat colour scores for each split.
    f. Microbiological data
        i. Collect swab samples from carcasses/sides immediately before entry into chillers, i.e. of hot carcasses.

ii. Swabs are collected on the same day, once per week.
iii. Swab three carcasses/sides from each split on each sampling day - i.e. total of 18 swabs (3 swabs/split X 2 splits/lot X 3 lots per day).
iv. Swabbing performed as per ESAM.
v. Samples transported at 4°C to the micro lab for *E. coli* counts and total viable counts (TVCs).

Details of the Klenzion Stock Washing System are available at http://www.aqwash.com/. The product is commercial in confidence. This product has been reviewed by AQIS, and deemed not requiring any particular permits for use on slaughter cattle – i.e. its components are not considered a welfare risk to cattle, or a health risk to humans, or an environmental risk. This permit was reviewed and issued using the Guidelines for the Approval of Chemical Compounds Used at Establishments Registered to Prepare Goods Prescribed for the Purpose of the Export Meat Orders (AQIS Technical Services Branch, 2005). The Australian Pesticides and Veterinary Medicine Authority indicated that it did not require registration for described use. The product is applied as a 1:40 dilution in potable water at a rate of 7-8L per animal using a patented (Application number: 71967/98; Grant Number: 747568) spray system. This involves passage of stock through a race that has specifically positioned spray nozzles that apply the product at the required rate and at the most important locations in terms of typical contamination and knife points during the slaughter process.

3.2.2 Cattle Cleanliness Assessment System

Cattle were ordinally scored as to their degree of hide soiling using a system originally described by Van Donkersgoed *et al. (6)*. Although containing subjective elements, the system is designed to reduce the amount of inter-rater variability in appraising cattle cleanliness. The reliability of this method, and further recommendations as to use of the assessment system have been described by Jordan *et al. (4)*. The scoring is performed essentially as follows:

1. Assess each animal at three specified locations
    - Side (left or right side but not both)
        - Lateral thorax and abdomen on one side only
        - Above the line joining elbow and stifle
    - Belly
        - From the sternum to the udder/scrotum
        - Below the line joining elbow and stifle on each side
    - Leg (left or right side but not both)
        - Entire hind leg and rump on one side only

2. At each location score 0, 1, 2 or 3
    - Based on the proportion of total available area that is covered with dag/tag.
3. Sum the scores from each location to obtain the whole animal score
4. Animal score is a whole number from 0 to 9
    - Total scores can be averaged out where individual location scores are between whole numbers.

Personnel involved in the assessment process were provided detailed descriptions of the system, including maps of scoring sites and photographic examples of typical scores.

3.3 Data Analysis

Data were collated and sorted using spreadsheets (Microsoft Excel), and statistical analyses performed using Stata 10 (Statacorp). Hosing times (minutes) and water volumes (L; based on mean water volume/minute calculations for the hose used) for treatment and control groups were compared using paired t tests and Wilcoxon rank-sum tests, depending on whether data conformed to parametric or non-parametric conditions. ANOVA was also used to assess the effect of other variables on treatment effect and wash times. Significant differences were assumed when *P* values were ≤ 0.05.

3.4 Personnel and Responsibilities

Organisation	Representative	Responsibilities and Tasks
Teys Brothers Beenleigh	Paul Day / Tom McGuire	Overall project management and facility operation. Coordination of Teys activities with AQIS, Klenzion and MLA considerations.
	David Summerville	Liaison with field operators and sample logistics. Field data collection and collation.
	Scott Williams	Quality assurance and field logistics.
	Katherine Hill	Quality and safety assurance. Microbiological analysis.
Australian Quarantine Inspection Service	Bruce Kirk David Grimmett	Ensuring that trial conditions allowed continuation of certification of product for export. Advice on practical cleanliness scoring.
Klenzion Limited	Michael Jones	Make available the applicator and chemicals and knowledge of the cleaning system and provide advice for the trial.
	Warren Jones	Cleaning system applicator set up and testing.
Meat and Livestock Australia	Ian Jenson	Financial management. Coordination of project partners. Consultation on industry impacts and technology transfer.
NSW Department of Primary Industries and Fisheries	David Jordan	Provision of and advice on use of the cleanliness scoring system. Consultation on scientific design and data analysis.
University of Queensland School of Veterinary Science	Rowland Cobbold	Scientific Project Manager. Final data collation and analysis. Principal report writer. Dissemination of results (scientific publications, presentations).

4 Results and Discussion

4.1 Project Execution and Timeline

The project timeline was extended beyond that originally proposed. The set up component of Milestone 2 was prolonged while issues of compliance regarding the use of Klenzion product and AQIS and Australian Pesticides and Veterinary Medicines Authority (APVMA) regulations were dealt with. Further delays occurred due to on-going negotiations between Klenzion and Teys Brothers with respect to product and process intellectual property transfer, and in ensuring that the spray cabinet and process set up at Teys Brothers complied with Klenzion specifications. The principal factor holding up progression of the project to full trials was drought, as the lack of wet conditions precluded presentation of cattle at slaughter with high degrees of hide soiling. More

heavily dagged cattle, or at least more variation in the degree of hide soiling, was needed to develop the cattle cleanliness vs. cleaning intervention matrix required for Objective 2. Some minor delays were also experienced due to changes in personnel and project management responsibilities at Teys Brothers.

Preliminary trials conducted at the completion of the set up phase were used to determine optimal trial execution and data collection protocols. Initially, the trial plan was to provide a standardised wash period for both Klenzion and control groups over each mob trialled, with cleanliness scoring of cattle both before and after washing. Assessment of the efficacy of the Klenzion system would be based on differences in pre-wash versus post-wash scores as compared to the control. This plan was changed to the final protocol (i.e. scoring pre-wash and comparing times between Klenzion and control split mobs to achieve satisfactory cattle cleanliness) for a number of reasons. Foremost among these were simple practical and logistical considerations – too much time and labour input was needed to score the cattle four times per mob. Use of time as the outcome variable also provided more objective, interval level data for analysis, and allowed for simpler calculation of water volumes required for hosing. The final scoring and data collection protocols adopted for later trials (as described in this report) were designed to be an equitable balance of practical and commercial feasibility with scientific rigour.

4.2 Efficacy of the Klenzion Cleaning Process

A total of 16 mobs were used within the trial, including two mobs run within the preliminary trial phase of the project. Mobs varied in their size (average of 60 head/mob) and the nature of the constituent cattle. A total of 948 cattle took part in the trials. Table 1 provides the raw data for each mob used in the trial. Table 2 provides basic descriptive and comparative statistics for the hosing times and water volumes used for both Klenzion and control groups. One set of mob data (Trial 4) was excluded from analysis as for both Klenzion and control treatment groups, the cleanliness end point was not achieved with maximal levels of hosing. Use of the Klenzion wash system resulted in significant reductions in both the time taken and water volume required to get cattle acceptably clean for slaughter. Similarly, the mean volume of wash water needed per head for the Klenzion system (75.3 L) was significantly lower ($P < 0.001$) than that for the control system (116.9 L). This may represent a conservative effect, as no in-line cattle rinse-off system (as is typically employed for the Klenzion system) was used in the current trial, which may have lead to further reductions in water and time consumption. Although hosing times and water volumes are significantly reduced using the Klenzion wash system as installed for this trial (without rinse-off system), the participating plant determined that this difference did not justify commercial installation of the system at the site. Although less hosing time was needed with use of the Klenzion system as installed, it was estimated that this would not translate to a reduction in the number of personnel required to perform this function. Thus, labour costs were not significantly reduced. Similarly, water use savings did not translate to a commercially significant reduction in expenses. This was in consideration that water being saved was primarily tertiary recycled water which is legally used for washing stock prior to the final rinse (except for the European Union market were water used for cattle washing must be potable). On the basis of the limited trials conducted, the company was not convinced that there was economic justification to permanently install the Klenzion system at the site at this time.

Carcase hygiene and production data was collected for three mobs only. No microbiological data or data on the prevalence of dark cutting carcases/sides was available. Due to missing data points and a low number of lots for this production data, descriptive and comparative statistical analyses were not attempted..

Table 1. Times and water volumes required to clean cattle to a level considered fit for slaughter and carcase production and hygiene data for cattle washed using a conventional water spray system and the Klenzion cattle wash system (as installed for this trial).

Trial	Date	Mob size	Mob desc	Score	Ktime	Kvol	Ctime	Cvol	Kmha	Cmha	Kpos	Cpos	Ktot	Ctot
1	Mar-07	30	Brahman X	2	6.2	1016	14.5	2375						
2	Mar-07	20	120d	3.5	5.5	893	12	1966						
3	Sep-07	30	grass	2	13.0	2129	18	2948						
4	Sep-07	40	70d steers	3	50+	8190+	50+	8190+						
5	Sep-07	68	trade steers	2	15.0	2457	20	3276						
6	Sep-07	55	trade steers	2	12.0	1966	22	3604						
7	Sep-07	51	trade steers	2	10.0	1638	16	2621						
8	Sep-07	60	100d	2	10.0	1638	15	2457						
9	Sep-07	90	70d steers	2	23.0	3767	28	4586						
10	Sep-07	90	70d steers	2	19.0	3112	24	3931						
11	Dec-07	90	70d steers	2	23	3767	28	4586	0	1	7	5	10	12
12	Dec-07	90	70d steers	2	19	3112	24	3931						
13	Dec-07	68	trade steers	2	15	2457	20	3276	2	0	7	4	21	7
14	Dec-07	55	trade steers	2	12	1966	22	3604						
15	Dec-07	51	trade steers	2	10	1638	16	2621	0	2	4	7	8	19
16	Dec-07	60	100d	2	10	1638	15	2457						

Mob desc = description of the cattle within each mob
Score = cattle cleanliness score using the system described
K = prefix for all Klenzion split-mob results
C = prefix for all control split-mob results
time = time required to hose cattle to a cleanliness level fit for slaughter
vol = volume of water required for above
mha = final meat hygiene assessment score
pos = number of sides/carcases demonstrating a defect during meat hygiene assessment
tot = total number of defects during meat hygiene assessment

Table 2. Descriptive and comparative statistics for hosing times and water volumes required for Klenzion treated and control cattle to be considered fit for slaughter.

	Time				Volume			
Parameter	**Klenzion**	**Control**	***P* (t test)**	***P* (Wilcoxon)**	**Klenzion**	**Control**	***P* (t test)**	***P* (Wilcoxon)**
mean	13.5	19.6	<0.001	0.004	2213	3216	<0.001	0.005
median	12	20			1966	3276		
minimum	5.5	12.0			893	1966		
maximum	23.0	28.0			3767	4586		

4.3 Development of an auditable cattle cleanliness assessment system

This objective could not be fully addressed, due to a lack of data in general (relating to numbers of mobs trialled) and a lack of diversity in hide cleanliness scores of cattle presented at the abattoir for slaughter. Because of drought conditions in the areas from which the abattoir sourced cattle over the trial period, very few mobs or individual cattle had dag scores beyond light soiling (score 3.5 or below). Although geographic areas and time periods that experienced relatively higher rainfall events were targeted for inclusion in the trial, sufficiently dirty cattle were still not forthcoming. This resulted in an inability to adequately trial the cleanliness assessment system and collate data over the full range of scores necessary to complete the cleanliness versus intervention matrix. However, trialling and initial development of the cleanliness assessment system under commercial conditions was achieved, and experiences from the current project will carry across to future projects that can more predominantly include this in their objectives. The current project also acted as a catalyst to discussions between industry and AQIS as to the potential regulatory acceptance of an auditable cleanliness assessment system, and how it might be included in plant operations and Approved Arrangements.

5 Conclusions and Recommendations

5.1 Impact on Meat and Livestock Industry

Although hosing times and water volumes are significantly reduced using the Klenzion system as installed, the participating plant determined that this difference did not justify commercial installation of the system at the site. This finding has merit in that it allows for redirection of resources towards interventions or protocols that are more likely to have significant impacts on process efficiency and product integrity. It also allowed the cleanliness assessment system to be trialled within a commercial setting, thus determining its proof-of-concept useability for future projects and in general. Although the Klenzion system could not be formally trialled on more heavily soiled cattle, anecdotal reports from project personnel indicated that although it was effective in assisting in the removal of superficial and lightly adherent hide soiling, it did not assist in the removal of widespread, thick, concreted dags. This is exemplified by Trial 4 (Table 1), where in excess of 50 minutes of hosing both the Klenzion treated and control groups did not satisfactorily clean the cattle. It must be emphasised that Klenzion does not claim to be efficacious for heavily soiled cattle, and was not recognised to be specifically deficient in this respect, in that no one product or process was likely to be effective at the slaughter stage in removing such material.

A significant inhibiting issue in executing this project was the lack of an objective scoring system which determined the level of stock cleanliness that was acceptable for slaughter at an export meat processing establishment that was commonly understood by AQIS and industry. Industry participants in the study report that the absence of such a system has been the cause of production disruption and dispute. Furthermore, should such a system ever be agreed, interventions such as the Klenzion system may make a valuable addition to the food safety/ quality assurance controls implemented by meat processors, in that they may assist in achieving objective measures which determine acceptability for slaughter. This may be complemented by recent changes in legislation in some export markets which may allow meat processors to use recycled water in lieu of potable water for the final cattle wash prior to slaughter. Industry representatives indicated that this potential would have significant benefits, and therefore is recommended for further investigation along with other cattle washing innovations.

The major conclusions from the current project with respect to industry impact are summarised as:

1. Issues relating to heavily dagged cattle being presented for slaughter continue to be a problem for beef processors.
2. Compounding this problem is a lack of consensus, both between personnel within a processing plant and between plants, as well as between AQIS staff and industry personnel, on how such cattle are classified as being unfit for slaughter on the basis of dirtiness.
3. It seems likely that no washing or similar cleaning intervention directed at heavy dagging and applied purely at slaughter will be effective in mitigating food safety hazards or improving processing efficiency, and that future resources would be better applied to either:
    a. Trialling products and/or protocols that minimise dag accumulation at the farm level
    b. Devising and trialling other interventions in addition to washing at the processing level to mitigate hazards associated with particularly heavily dagged cattle, e.g. increased carcase inspection and/or trimming, logistic processing.
    c. Developing a more objective and auditable cattle cleanliness assessment system that can be integrated into existing quality assurance programs such that future

interventions can be targeted to the higher risk cattle and be more effectively monitored.

5.2 Scientific and Technical Impacts

Several limitations to the current project can be identified, and include:

1. The employed cattle cleanliness assessment system retains elements of subjective appraisal. Although the subjectivity is reduced and compartmentalised using the cleanliness assessment system described by Jordan *et al. (4)*, further development of the assessment system or training systems relating to use of the scoring system to minimise inter-rater error would be valuable.
2. Similarly, subjectivity in what was considered fit for slaughter with respect to cleanliness was a confounder for the current study. This was overcome to some degree by using the same person to judge slaughter acceptability for both Klenzion and control groups, and blinding as to treatment for the cattle hoser. Consultation between abattoir and AQIS personnel is important in the process of determining cleanliness acceptability, and would need to be included in any future projects working towards improving cleanliness or scoring of cleanliness.
3. The water volume outcome variable was directly linked to time (was derived from the flow rate of the washing hose), so was not a truly independent measurement. Also, use of water in this capacity was not entirely representative of the entire water use equation. Future studies should aim to collect data on total water use for both systems, i.e. including that used in the Klenzion spray cabinet, control spray systems, rinse systems, etc..
4. A major limitation to the current study was availability of cattle of varying dirtiness for more widespread testing of the cleanliness assessment system and of the Klenzion system. Future studies should target plants that source cattle from more temperate areas where dirty cattle can be more reliably trialled. Trials conducted over a variety of plants would better ensure a variety of cattle soiling levels, and be useful in validating the inter-rater and inter-plant reliability and practical feasibility of a cattle cleanliness assessment system.
5. For future studies, microbiological data beyond standard *E. coli* and *Salmonella* (ESAM) testing data needs to be actively collected. Similarly, production data, including relevant quality data (e.g. dark cutting incidence) needs to be collected over a large number of lots to satisfy statistical requirements for determining effects of cleaning and/or original hide cleanliness.

6 Bibliography

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7 Appendices

7.1 Appendix 1 – Dag Scoring Sheet

TAG SCORING SHEET

DATE________________ **SCORER**___________________

Lot No.__________ **LIGHT SOILING**

ID No.	Side				Leg				Belly				TOTAL
	None	Light	Med.	Heavy	None	Light	Med.	Heavy	None	Light	Med.	Heavy	
If needed -	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	Scorer
don't have to	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	does not
record IDs for	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	need to
each animal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	tally
as long	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	these in
as not scored	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	the field
twice	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Treatment allocation	
Split ID - Treatment	e.g. coded number for split, colour-marked cattle, marked pen
Split ID - Control	

Lot No.__________ **MEDIUM SOILING**

ID No.	Side				Leg				Belly				TOTAL
	None	Light	Med.	Heavy	None	Light	Med.	Heavy	None	Light	Med.	Heavy	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Treatment allocation	
Split ID - Treatment	
Split ID - Control	

Lot No.__________ **HEAVY SOILING**

ID No.	Side				Leg				Belly				TOTAL
	None	Light	Med.	Heavy	None	Light	Med.	Heavy	None	Light	Med.	Heavy	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Treatment allocation	
Split ID - Treatment	
Split ID - Control	

7.2 Appendix 2 – Wash Data Sheet

WASH DATA SHEET

Date_____

Washer_____

Recorder_____

Lot Id	Split Id	Dwell Time	Wash Time