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FACTORS CONTRIBUTING TO THE MICROBIOLOGICAL CONTAMINATION OF BEEF CARCASES

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Preface

This project was conducted by Meat & Livestock Australia with the assistance of:

Food Science Australia
Primary Industries Research, Victoria
South Australian Research & Development Institute

MLA wants to acknowledge the cooperation of the Australian Meat Industry Council, Australian Quarantine Inspection Service and the large number of processors who accepted the invitation to participate in this project.

1 Introduction

There are many factors that can affect the microbiological quality of carcases: the cleanliness of cattle, how stressed the cattle are, the procedures used for removing the hide, evisceration, dressing and chilling. In Australia, where all export registered establishments meet the requirements of the Australian Standard and the Export Meat Orders, and are supervised by the same controlling authority there are large differences between the microbiological quality (as measured by the *E. coli* and *Salmonella* monitoring program - ESAM) of carcases at one abattoir compared to another.

This project was undertaken to try and find out why some establishments consistently have low *E. coli* prevalence in their ESAM testing while others have higher prevalence. Prevalence means the percentage of ESAM samples that were found to contain *E. coli*. We used prevalence because it is a simple way of summarising all the data and because it was thought that establishments with higher prevalence would also have higher average counts.

We didn't expect that this project would determine exactly what an establishment could do to improve microbiological quality of carcases, but we did expect that we could identify areas that needed to be investigated further.

2 Background

Fifteen plants agreed to participate in the project, each was visited by researchers and supplied answers to a questionnaire which asked about:

- Livestock slaughtered (tag score, proportion from feedlot, travel time)
- Slaughter and dressing technique
- Chain speeds
- Staff training and turnover

3 Analysis of the questionnaires

First the researchers looked to see if answers to any one question showed some correlation with the prevalence of *E. coli*, but there didn't seem to be.

Next, similar questions were grouped together and a score developed (we called these 'factors'). The data were given numerical weightings by the researchers according to the likely effect on contamination and its control. For example, some plants used hot water interventions, others used an acid wash intervention, while most plants did not have an intervention to reduce bacterial loadings on the carcase. The researchers used a weighting of 5 for acid wash and 10 for hot water wash because they thought an acid wash gave an approximately 5-fold reduction and hot water a 10-fold reduction compared with no intervention. None of these factors taken alone seemed to give a good correlation with the prevalence of *E. coli*.

Finally, the researchers looked at a combination of two big factors:
1. The extent of the contamination problem facing each plant on incoming livestock (the Problem)
2. The effectiveness of the slaughter and dressing process (the Process)

4 Results

4.1 Estimating the problem

The researchers selected what they thought were the most important factors involved in bringing contamination into the plant on the live animal.

These factors thought to be most important were
- the proportion of feedlot stock,
- the length of transport (medium [12-48hrs] or long [>48hrs])
- the degree of hide contamination or tag (moderate to severe).
- the proportion of cows/bulls processed (cows and bulls are considered to add to the Problem)

It is possible that some of these factors interact. For example, feedlot stock may always have more tag and animals transported for longer times may also have more tag. Consequently, the problem may not simply be due to the amount of tag, but also due to whether animals come from feedlot or were transported long distances.

A 'Problem Score' was developed that incorporated feedlot percentage, length of transport and degree of tag. The scores ranged from 0.02-5.04 (approximately 250-fold range).

The proportion of cows and bulls processed seems to have an effect. Based on national ESAM data, typically cows and bulls have higher *E. coli* prevalence than steers/heifers (Table 3); varying from 6-8% over the years 2000-2003 for cows/bulls and 3-4% for steers/heifers over the same period. Having said that, some plants processing a large proportion of cows and bulls seem to be able to manage the situation well.

The contamination level on incoming livestock is the first important factor because it makes if more difficult for the process to cope with the contamination load. The important factors contributing to contamination level appear to be:

- Cleanliness of hides
- Time of transport
- Proportion of cows/bulls

4.2 Measuring effectiveness of the process

The researchers next assembled a list of factors which they judged to have high importance for an effective slaughter and dressing process.

The “Process Score” was based on what is known about the microbiological efficacy of the particular processing stages or, when such data were lacking, expert opinion. The ‘Process Score’ was developed to indicate the effectiveness of the process in coping with incoming contamination and ranged from 0.2 to 320 – larger values indicate that the process is less effective.

The researchers considered a “good” process would incorporate the following techniques:

- Double knife sterilising (especially for opening cuts) and spear cuts to open the hide
- Downward hide pulling especially in an area physically separated from hide-off area
- Evisceration table with integrated station for operator to clean/sanitise equipment and hands
- Automatic washing of the whole carcase
- Decontamination as an intervention step

Other factors were considered e.g. line speeds and manning rates, training/turnover levels of staff but they were found not to be as important as the factors listed above.

A number of slaughter and dressing practices appeared to be important in achieving good carcase microbiological quality:

- Effective separation of hide-on and hide-off areas
- Evisceration straight onto evisceration tables
- Use of decontamination interventions

4.3 Analysis

The researchers then analysed the data by linking the problem of incoming stock with effectiveness of the process. If the system used for developing the Problem score and Process score was successful, then it should be able to predict the prevalence of *E. coli* on carcases (or at least indicate whether the prevalence is low, medium or high).

Figure 1 shows how the Problem and Process scores are associated with the prevalence of *E. coli*. Figures 2 and 3, show then show the Problem and Process scores one at a time. The colours are used to identify points in the following discussion.

A good way to read these charts is that plants with low *E. coli* prevalence are near the bottom and plants with high prevalence are at the top of each chart. In Figure 1, plants with good Problem and Process scores are towards the centre. In Figure 2, plants with a low incoming contamination problem on livestock are towards the left of the chart; the bigger the problem, the farther to the right side of the chart. In Figure 3, plants with a better than average process are towards the left side; those with a worse than average process are arranged towards the right.

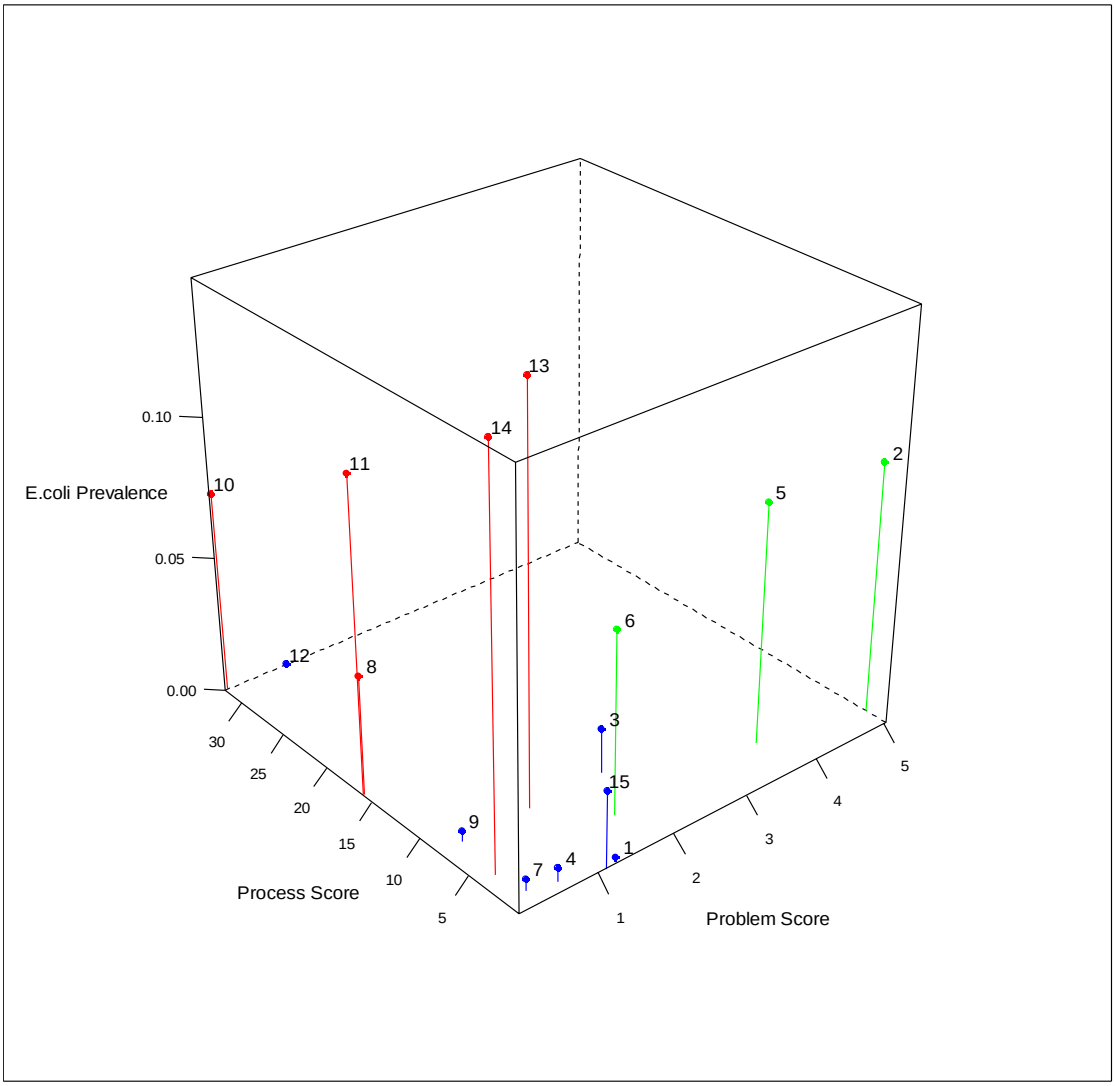

Figure 1: Relationship of E. coli prevalence to Problem and Process Scores

Plants with an effective process

The cluster on the bottom left (blue box) portion of Figure 3 represents plants which have an effective process:

- Some plants use hot water decontamination
- Other plants have a process which is able to cope with an apparently high loading on livestock

Plants with an incoming problem, not solved by the process

The cluster bounded by the green box have prevalence of *E. coli* which suggests the process does not entirely reduce the loading on highly contaminated stock.

Plants with little incoming problem and an apparently ineffective process

Plants bounded by the red line generally have little incoming problem with their livestock (short haul, low tag scores, low proportion of feedlot cattle) but have lower than average scores for slaughter and dressing. The analysis did not completely resolve the differences between these plants.

Plants that are difficult to categorise

One plant reported very low *E. coli* prevalence but did not appear to have a process that was particularly effective in reducing *E. coli*. The researchers were unable to account for low *E. coli* prevalence of this category, unless the problem was so low, that the process was not really called upon to cope.

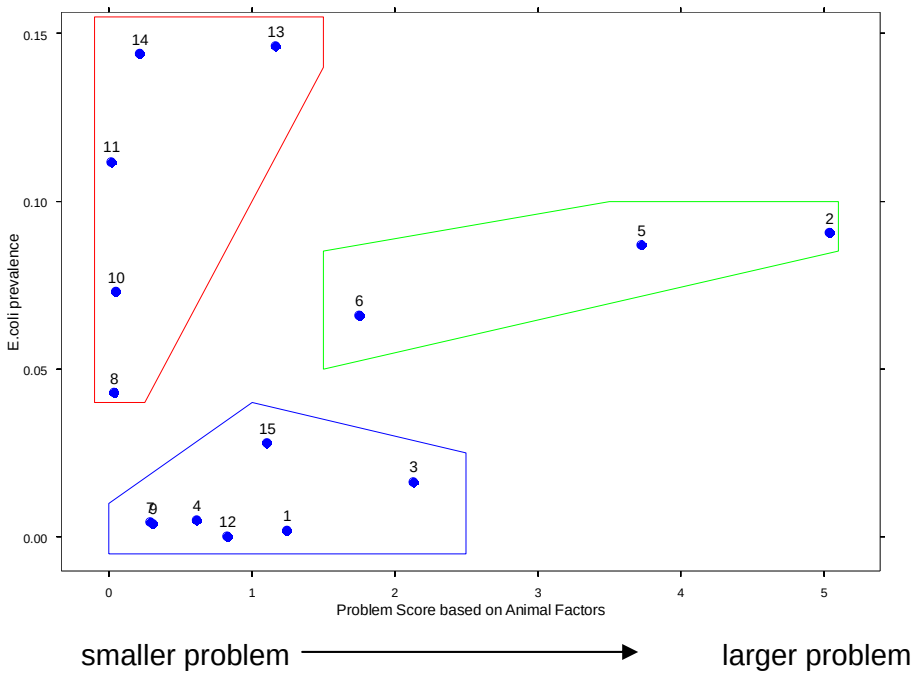

Figure 2: *E. coli* prevalence versus livestock contamination score

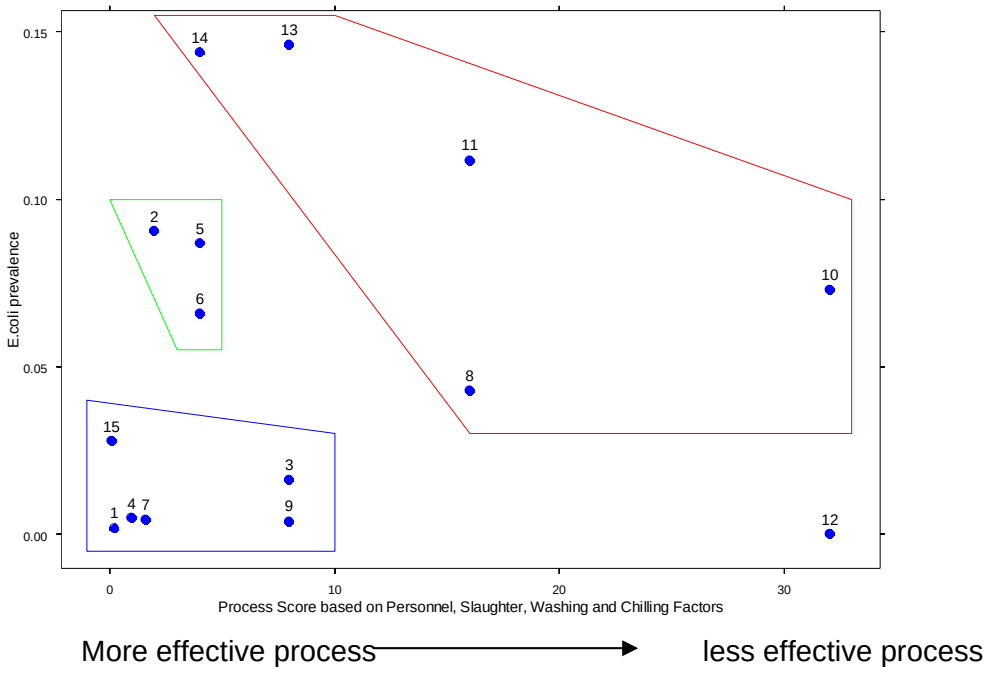

Figure 3: *E. coli* prevalence versus process effectiveness score

Table 3: Prevalence and concentration of *E. coli* on Australian export beef carcases (2000-2003)

	Steers/heifers				Cows/bulls			
	2000	2001	2002	2003	2000	2001	2002	2003
Number tested	14399	14370	14536	13595	7093	6924	7255	7514
Number (%) positive	626 (4.3)	451 (3.2)	481 (3.3)	409 (3.0)	573 (8.1)	425 (6.1)	584 (8.0)	536 (7.1)
Median	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
80th percentile	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
95th percentile	Not detected	Not detected	Not detected	Not detected	0.2*	0.08	0.08	0.08
98th percentile	0.2	0.16	0.16	0.08	0.8	0.4	0.4	0.4
Maximum	1750	763	42	8300	301	154	416	300

*cfu/cm^2

Table 4: Distribution of *E. coli* prevalence from steers/heifers according to season (unusually high prevalence marked in red)

	Prevalence of *E. coli* (%)				
	Summer	Autumn	Winter	Spring	Overall
Plant 2	4.6	11.3	9.1	9.9	8.8
Plant 5	8	4.9	16.3	6.8	8.7
Plant 6	9.9	1.2	4.2	7.8	5.6
Plant 8	3.8	8.7	5	4.1	5.3
Plant 10	0	0	0	0	0
Plant 11	0	7.7	60	0	13.7
Plant 13	5.9	0	12.5	0	3.3
Plant 14	29.5	20	21.4	1.2	22.9

Table 5: Distribution of *E. coli* prevalence from cows/bulls according to season (unusually high prevalence marked in red)

	Prevalence of *E. coli* (%)				
	Summer	Autumn	Winter	Spring	Overall
Plant 2	0	16.6	14.3	33.3	13.8
Plant 5	0	0	0	0	0
Plant 6	4.7	9.3	7.6	12.6	9.1
Plant 8	3.4	2.9	7.1	0	3.4
Plant 10	7.8	6.4	7.5	7.7	7.3
Plant 11	0	4.0	25	17.0	10.3
Plant 13	0	40	33.3	14.3	23.4
Plant 14	5.9	11.9	12.3	6.2	9.1

5 Overall Conclusions

The researchers attempted to find groupings of plants, based on problem and process variables, to help plants understand why they have a higher or lower *E. coli* prevalence than others.

The factors used to group the plants suggest that these factors may have some influence on the *E. coli* prevalence and therefore the hygienic quality of carcases produced. This work does **not** prove that the selected factors have a direct effect on *E. coli* prevalence. Further investigations are required before we can draw conclusions about how to reduce the prevalence of *E. coli* on carcases.

The good news from this work is that some of the factors identified can be controlled or changed by the processing establishment. This suggests that there is a way in which establishments with a higher prevalence of *E. coli* can reduce that prevalence should they wish to do so.

Some Canadian, researchers give an example of how they improved the microbiological quality of some plants in Canada. There were large differences in microbiological status of carcases and observed differences in processing centred around the way work was arranged. At one plant, the researchers recommended small changes to the hindquarter skinning process:

1. Start skinning by cutting a strip of skin from navel to crotch.
2. Cut 3cm rather than 1cm from the anus
3. Trim fat along the opening incision
4. Just make opening cuts, rather than extending the work

One plant instituted only recommendations 2 and 4 but still made significant improvement in carcase quality, reducing the bacterial loading by more than 90%.

MLA wants to work with processors to be able to improve microbiological quality in Australia. From the work described here we think that it would be important to investigate:

- Effective ways of cleaning hides prior to opening cuts
- Understanding whether time of transport is important because it contributes to hide contamination or for some other reason
- How to effectively separate hide-on and hide off areas
- Effective methods of dressing cows/bulls

A lot of useful information could be gained by working with individual processors to take more measurements on their process. It would also be good to collect data over many days of operation to investigate the effects of animal factors with carcase microbiological contamination. If a processor was considering making any changes to their process then it would be good to make a comparison of the process ‘before’ and ‘after’ in order to assess the effectiveness of the change.

MLA is interested in working with processors who want to understand more about their process. We would be interested in working with sites to help us understand these areas of processing and could financially support work done at processing sites.