Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

UV Project GMP

UV-C System Installation

Project code
2022-1165

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Date submitted
01/4/2025

Published by
AMPC

Date published
01/04/2025

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1.0 Abstract

Gundagai Meat Processors installed a UV and ozone treatment unit with the chillers to achieve air purification and a UV unit within the hot DEXA to achieve carcase sterilisation. A design stage was included prior to the installation of the UV and ozone units. Throughout the installation phase of the project a large amount of work was undertaken to ensure the safety of workers undertaking tasks within the install areas. After installation of the units, baseline air samples and carcase swabs were undertaken prior to turning the UV and ozone units on. After installation a range of air samples and carcase swabs were undertaken to determine the total fungal structures in the air, and the total viable counts on carcases. It was found that there was no difference in total fungal structures when comparing the baseline air samples to the UV and ozone treated samples. The reason there was no difference could have been due to the size of the UV and ozone unit installed, with investigation into the installation of a larger unit required. There was a measurable difference in total viable count due to carcase sterilisation with UV light within the hot DEXA unit. Further work involving the UV unit installed within the hot DEXA unit is required to further validate results. Overall, the project was able to demonstrate the effectiveness of using UV light directly on carcases to reduce total viable count, however, no measurable difference was found when applying UV light and ozone to the air within the carcase chillers.

2.0 Executive summary

Gundagai Meat Processors installed UV and ozone treatment for air purification in the carcase chiller area of the plant. The installation of UV lights within the hot DEXA unit for purification directly on the carcase was also undertaken. This project was undertaken to determine whether UV and ozone exposure to the air circulating in the plant could reduce fungal structures to improve shelf life of product and human health. The installation of UV light in the hot DEXA was undertaken to determine if this application does reduce total viable count and increase shelf life days of product as a result.

This project was undertaken through several steps. The initial idea was circulated to determine if there was support, the design was then developed prior to the installation of the system. The installation of the system was undertaken with a large amount of work undertaken to ensure the system that was installed was safe for workers. The use of guarding was used to ensure that workers were not exposed to UV light directly whilst working in different areas of the plant.

After installation of the UV and ozone unit and the UV unit within the hot DEXA, a range of samples were taken within each area. Within the chillers air samples were taken to determine a baseline result within the chillers. Within the DEXA unit swabs were taken on carcases that had not been exposed to UV light. The units were then turned on and sampling continued.

The results shows that the UV and ozone unit did not produce a measurement reduction in fungal structures within the chillers they were installed within. This was a disappointing finding, with further work required to determine if an increase in unit size would produce a measurable decrease. The UV lights installed within the DEXA unit shows a measurable decrease in total viable count. It was pleasing to see a measurable decrease, with more work required to further validate the system installed.

This project was able to demonstrate the effectiveness of the installation of UV lights to directly sterilise carcases, however, there was no measurable outcome when UV light and ozone was installed in the chillers to treat the air.

3.0 Introduction

Maintaining and improving lamb product shelf life can, at times, be challenging for meat processing plants, with labour shortages and variable livestock posing the greatest risks. Additionally, ensuring that staff are safe and healthy is another priority for meat processing plants. Domestic and export markets have expectations regarding shelf life and the operation of meat processing plants. This project was initiated to address ways that the shelf life of product could be lengthened and how the safety and health of employees at Gundagai Meat Processors could be improved. This was undertaken by installing UV light and ozone application within the carcase chillers and boning room to sanitise the air moving through the plant. Additionally, the installation of UV light applied directly to the carcase at the end of the slaughter floor was undertaken to determine the effect of UV application on microbial levels on the carcase surface.

4.0 Project objectives

The project objectives include the following, as outlined within the project agreement.

- Reduction in strength of chemicals used to wash the plant.
- Reduction in spread of airborne diseases.
- Reduction in positive swab tests.
- Total conveyor sanitisation, in small moving parts.
- Less use of sanitising agents left overnight on equipment and residue.
- Peace of mind, that the plant is consistently being sanitised.
- Back up for human intervention.
- Manages Risk: Improved environmental hygiene means improved clinical outcomes, reduced cross-contamination and enhanced food safety.
- Kills unseen moulds and spores before detection.
- Reduces risk of a super spreader event.

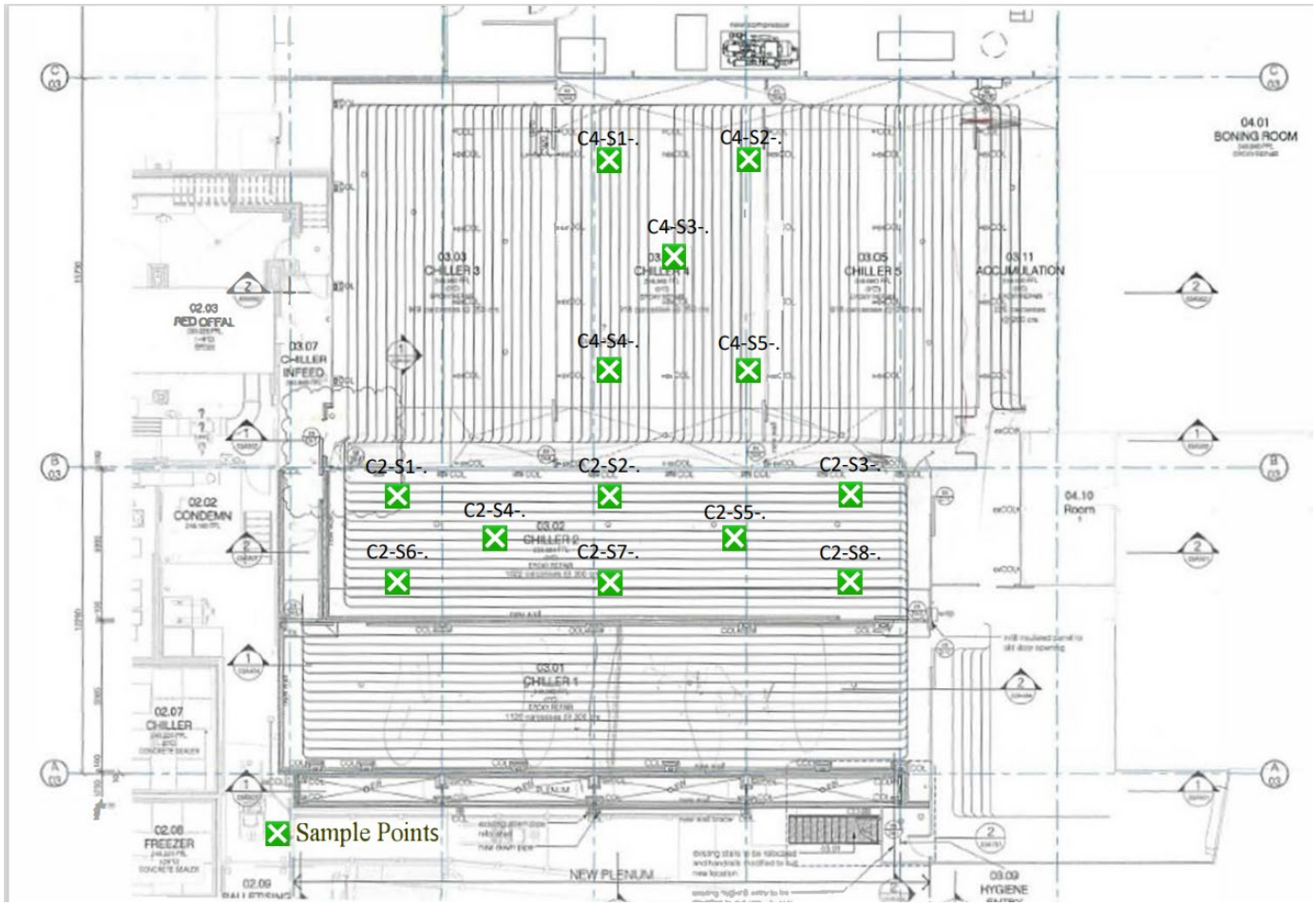
5.0 Methodology

This project was undertaken through a multi-step process.

1. Internal awareness was raising, promotion, and idea generation of the project, and conceptual designs for the business to review.
2. Development of a draft preferred design / layout for review by GMP and AMPC.
3. Installation and evaluation of preferred design.
4. Safety was considered with guarding installed to ensure people were not exposed to UV light directly when working in different areas of the plant.
5. Ongoing high-level management and reporting of data collected from the room / rooms, including generation new additions and initiatives to add to the system.
6. Initiate project into segments, to monitor step by step project outcomes.

7. Testing of air samples when the UV and ozone was turned on and off to determine if there was a difference in air sample results. Samples were sent to Indoor Environmental Consulting and Labs for analysis.
8. Swabbing of carcases for determination of microbial levels that had exposure to UV light and did not have exposure to UV light directly to the carcase. Samples were sent to Indoor Environmental Consulting and Labs for analysis.
9. Comparison of results to determine the effect of UV and ozone on air and carcase microbial levels.

Air samples were taken weekly, with five samples taken at each of the 27 sampling dates. Within chiller 2 eight sampling dates were scheduled before the UV was turned on, with 19 sampling dates after the UV was turned on. In chiller 4 9 sampling dates were schedule before with the remaining 18 sampling dates after the UV was turned on.



6.0 Results

Sampling of air was undertaken within chiller 2 and chiller 4 where the UV and ozone had been installed.

A preliminary look at the data shown in table 1 indicates that there was a lot of variability in results collected (standard deviation). However, the variability was higher in chiller 4. There was no clear

reduction in total fungal structures when comparing the overall pre UV result to the post UV result. When considering the combined chiller two and four results there was no large difference in average results.

Table 1. Average total fungal structures in chiller 2 and 4, pre UV and ozone and post UV and ozone, with the difference and standard deviation displayed.

	Pre UV and ozone	Post UV and ozone	Difference	Standard deviation
Chiller 2	169.7	148.7	-21.0	191.3
Chiller 4	175.7	227.2	51.5	224.2
Chiller 2 and 4 combined	172.2	178.9	6.7	206

The data was analysed to determine the distribution of results in a violin graph given in Figure 1 below. As can be seen there was greater variability in results when the UV and ozone was turned on, which could be influenced by the greater number of sampling days. The majority of results were below 250 total fungal structures when the UV and ozone was turned off and on. The outlying values during the on phase could have been influenced by sampling regime, however, there was no clear difference in the distribution of values

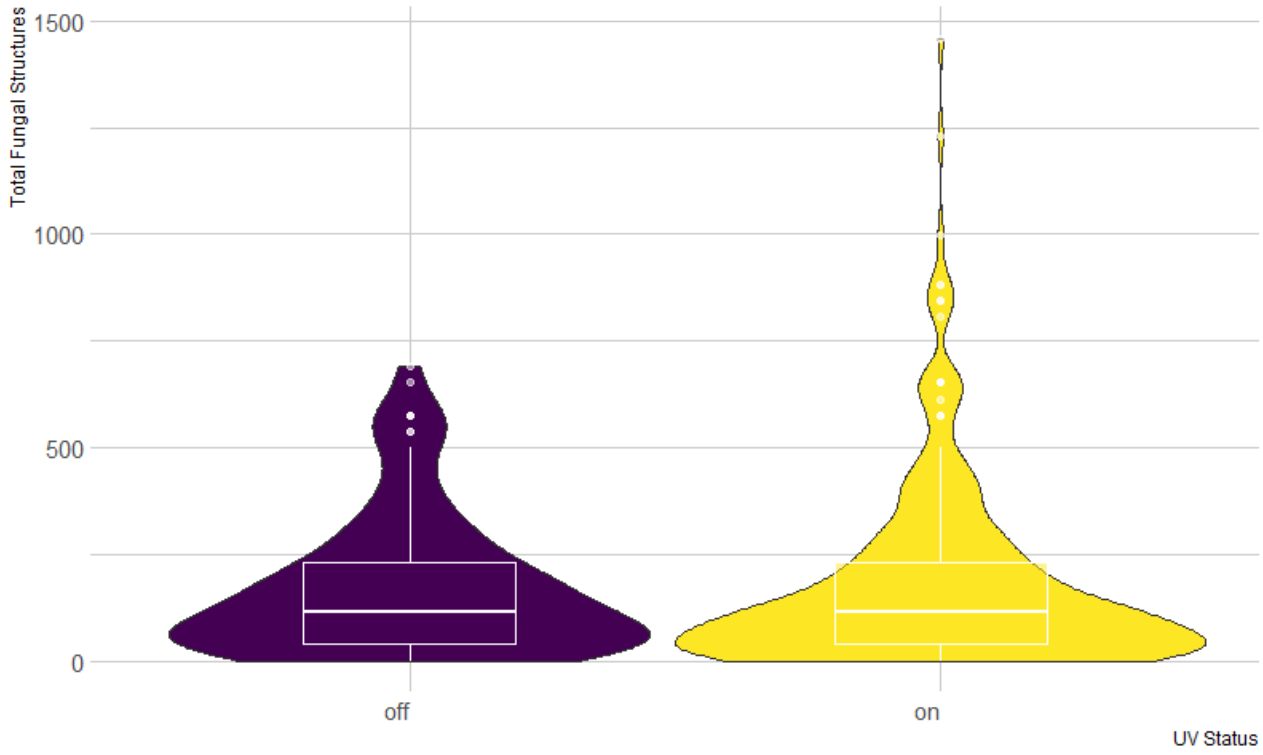


Figure 1. Violin distribution figure showing the distribution of total fungal structures when the UV and ozone was off versus on in chillers 2 and 4 combined.

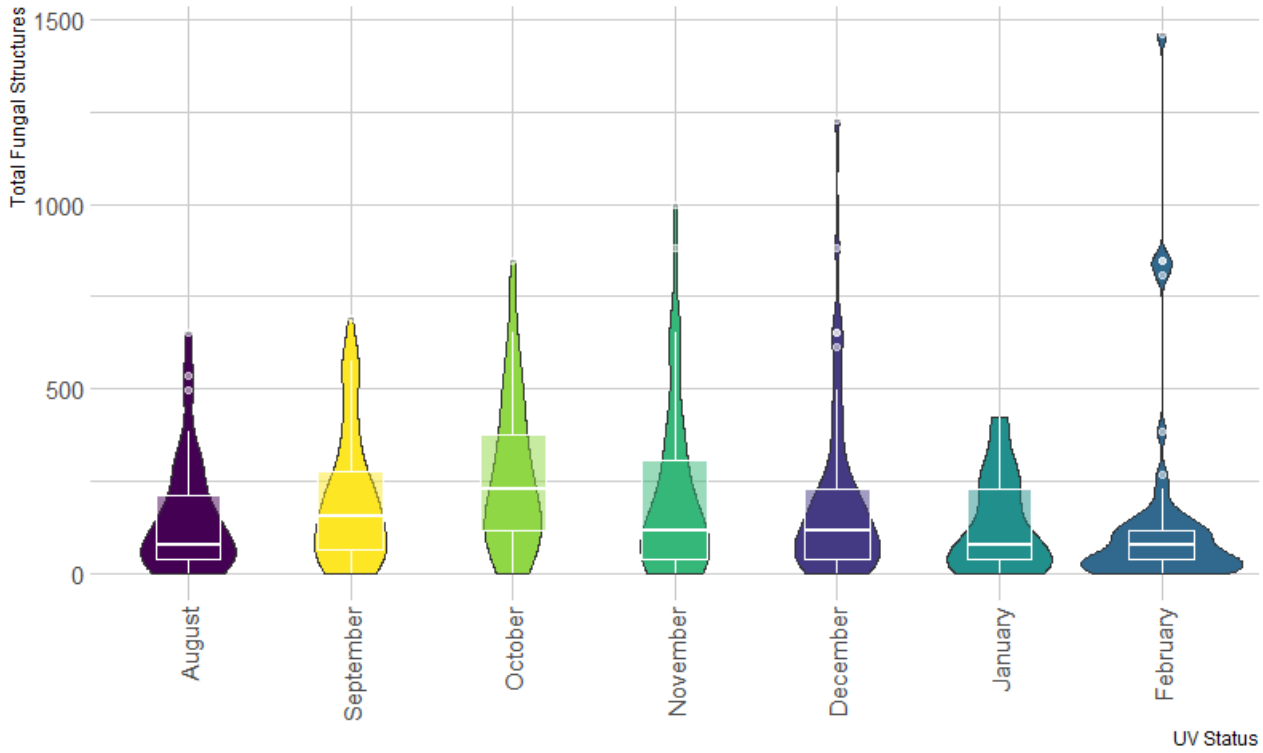


Figure 2. Violin distribution figure showing the distribution of total fungal structures when the UV and ozone was turn off (August and September), and on (October onwards) for chillers 2 and 4 combined.

The dataset had a lot of noise as can be seen in the distributions given in figure 1 and 2. To remove some of this noise, an average for each month was taken to visualise the dataset over time when considering average total fungal structures. As can be seen in figure 3, average total fungal structures increased over time between July and September, when the UV and ozone was turned on, average total fungal structures was at it's peak and declined from that time point on wards. However, there was a lot of variability in results when the UV and ozone was turned off and when turned on, which produces uncertainty as to the benefit of the current UV and ozone system installed at GMP.

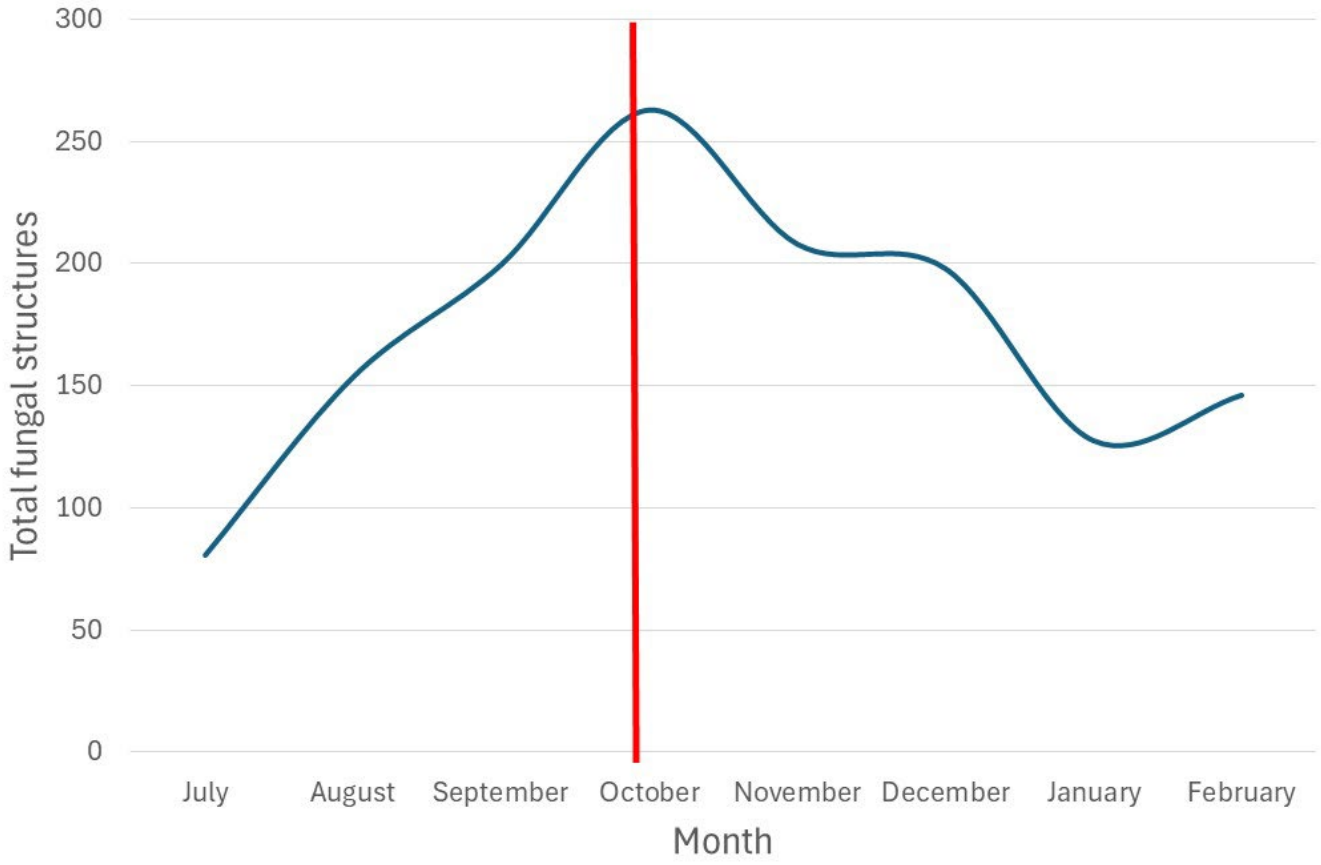


Figure 3. Line graph showing average total fungal structures over time (Month). The red line marks when the UV and ozone was turned on. The UV and ozone was turned off from July to September (red line signifies when the UV and ozone was turned on).

UV was also installed within the DEXA at GMP to treat carcases directly moving past the UV unit. Two different testing regimes were undertaken to visualise the effect of UV sterilisation directly onto a carcase. Figure 1 shows historical swab total viable count information, with markers indicating when the UV was turned on and off. As can be seen when the UV was not turned on there were much higher in relation to total viable count and spikes in total viable count, as compared to when the UV was turned on. Further when considering these results in table 2, when the UV was off the average total viable count was 131, whilst the UV off standard deviation (68% of values were within one standard deviation of the mean, whilst 95% of values were within two standard deviations), the standard deviation when the UV was turned off was large, indicating that that the values tend to not be close to the mean, and that there is more variability. When the UV was turned on the total viable count average dropped to 37, and there was much less variability with a tendency for the values to be closer to the mean. The UV on standard deviation was only 26, which indicates that 68% of values were within 26 units of the mean, whilst 95% were within two standard deviations. There were not a lot of values to use in this data set with only 10 samples taken when the UV was on and 118 when the UV was off. Thus another trail was undertaken.

Table 2. Average total viable count and standard deviation of total viable count for moving past the DEXA UV unit when it was turned off and on.

	UV off average	UV off st dev.	UV on average	UV on st dev.
Total viable count	131	227	37	26

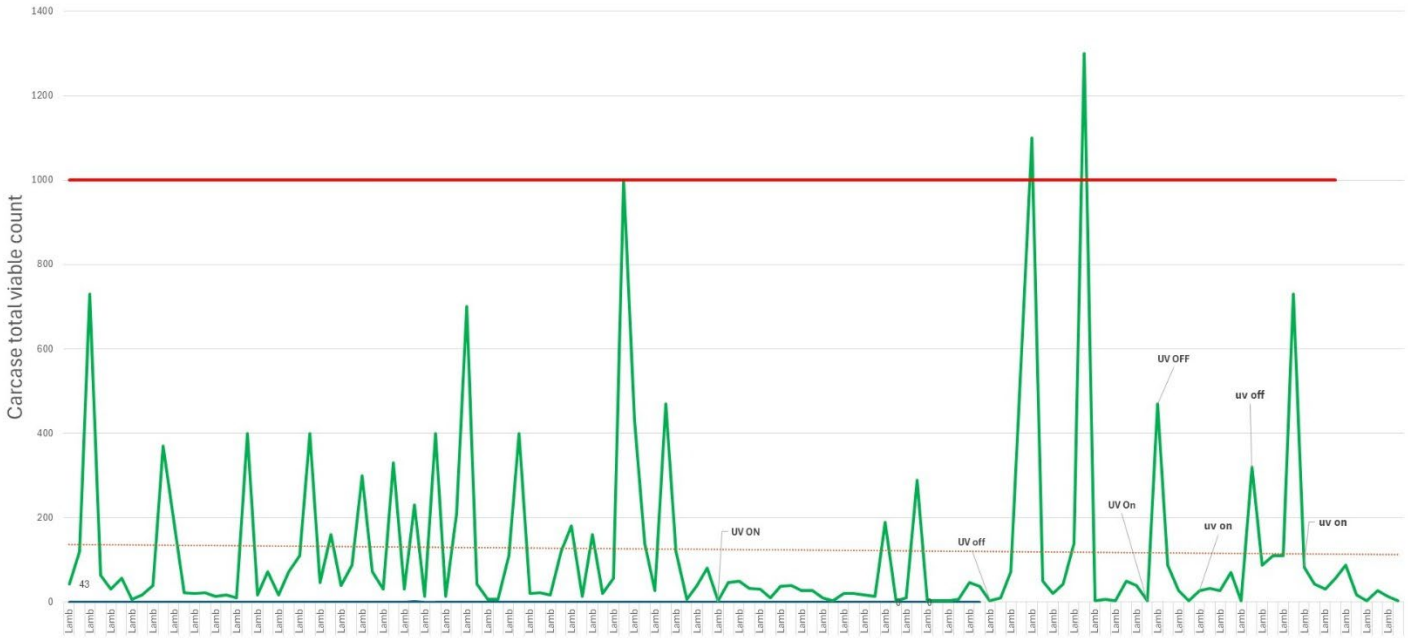


Figure 4. DEXA UV results including maximum carcase total viable count (TVC), and maximum carcase E.Coli over time. The time point when the UV was turned on is given on the figure.

As can be seen in figure 5, an on and off trial was undertaken over a total of 22 days. The UV was turned off for one week, and on for one week. This pattern repeated itself for 4 weeks, with two periods off and two periods on, switching each week. The results show a similar pattern to the first UV DEXA trial data. When the UV was off there were some peaks in results which resulted in a higher average result and greater variability in total viable count. When the UV was on the average result was much lower, indicating that the peaks that can be experienced in total viable count can be removed by the use of UV, resulting in a much lower standard deviation value. The peaks in results are shown clearly in Figure 5 below.

Table 3. Second UV DEXA trial results for total viable count, including UV off average, UV off standard deviation, UV on average, and UV on standard deviation.

	UV off average	UV off st dev.	UV on average	UV on st dev.
Total viable count	194	239	40	28

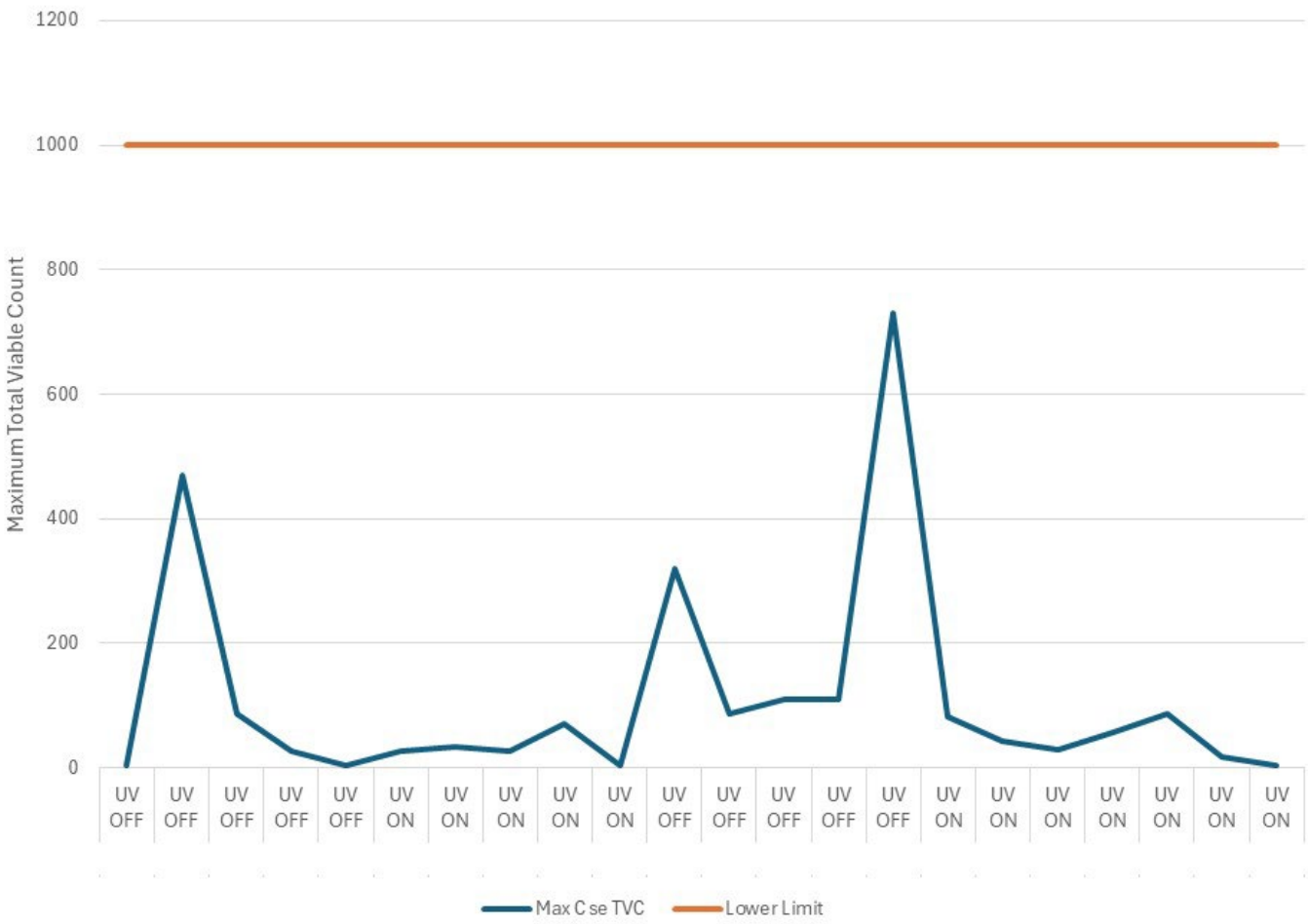


Figure 5. Total viable count results from carcases that passed through the DEXA with the UV turned on and off.

The shelf life prediction tool developed by the University of Tasmania, with MLA in 2017 was used to determine the shelf-life benefit of reducing total viable count from the peak values seen of 1000 to 100. The extra shelf-life days due to the reduction in total viable count was found to be 8-10 depending on the holding temperature used (8 days at -0.5degC, and 10 days at -1.0degC).

7.0 Discussion

The installation of UV and ozone at Gundagai Meat Processors did not show any clear and significant results in relation to the reduction of fungal structures in the air samples taken. There was a lot of variability in results which prior to the UV and ozone being installed and after the UV and ozone was turned on in the chillers. This could be due to the size of the equipment installed, not providing a measurable benefit to the fungal structures detected in the air samples taken. Further work to determine whether a large size unit is required needs to be undertaken to determine if there is a measurable benefit to air quality, and therefore, product quality and human health within the GMP plant. The disappointing results suggest that further work needs to be undertaken to determine if an increase in size of equipment installed would provide measurable decreases in fungal structure in the air.

Conversely, the installation of the UV unit with the hot DEXA at GMP showed measurable differences in the total viable count from swab samples taken from carcases. There were two tests untaken to provide an indication of the effect of UV sterilisation directly on the carcase. The first included looking at results from carcases whilst the UV was turned off. Historical carcase swab data was used for this exercise, with the addition of a small number of swabs taken on carcases after the UV was turned on. The second test was undertaken by turning the UV unit off for one week, followed by turning the UV unit on for one week. This was repeated over 4 weeks. The results clearly show a noticeable decrease in total viable count from carcase swabs taken whilst the UV was turned on, with a decrease in total viable count from 194 whilst the UV was turned off to 40 whilst the UV was turned on. The use of UV directly on carcases removed the spikes in total viable count that can be observed in figures 4 and 5 whilst the UV was turned off. The increase in shelf life days by 8-10 is a significant uplift in product shelf life in an export plant. Further work needs to be completed with the UV unit installed in the hot DEXA. There are three future focus areas that GMP would like to undertaken.

1. The forequarter area of the carcase is a variable distance from the UV lights given the variation in size of carcases. Determining whether the use of an automated distance regulator that the UV lights are mounted on is required to improve total viable count on the forequarter area of the carcase is one area that require future focus.
2. Can a greater reduction in total viable count be achieved by extending the length of the UV tubes and therefore the time the carcase is exposed to the UV lights?
3. The effect of dirty tubes on the effectiveness of the UV lights needs to be investigated to determine how often they may need cleaning.

8.0 Conclusions

In conclusion, the installation of the UV and ozone within the chillers did not show a marked improvement to fungal structures from air samples. There was a lot of variability in results before and after the installation and use of UV and ozone. The investigation into whether a large UV and ozone unit would produce measurable results needs to be investigated in future. The installation of the UV unit within the DEXA showed a measurable improvement in total viable count taken from swabbing carcases. The UV was able to remove any spikes in total viable count that were clearly observed with the UV unit was turned off. Shelf life, when estimated using the shelf life prediction tool, was found to increase by 8-10 days by removing the spikes in total viable count, a significant result for an export plant. Further work to test the effectiveness of the application of UV directly on a carcase needs to be undertaken, with further work required in three main areas. 1. Determining whether UV light can be applied to the forequarter area more effectively, 2. Does longer exposure to the UV lights result in a greater reduction in total viable count, 3. Do dirty UV light tubes result in a measurement decrease in effectiveness of the UV light unit, and if so, what cleaning regime should be put in place to ensure great effectiveness of UV light exposure.

9.0 Recommendations

Recommendations coming from this project include the following:

- The size of the UV and ozone unit should be determined with greater accuracy prior to the installation of the unit within the FDC's. The results from the current installation did not show a measurable difference on fungal structures from air samples.
- Further work is required to determine if the UV and ozone unit should increase in size and whether this would result in a measurable decrease in fungal structures.
- Initial results from the installation of the UV unit to directly sterilise carcases at the end of the slaughter floor measurably decreased the total viable units measurement on carcases, and resulted in a increase in shelf life by 8-10 days. The installation of the UV unit to directly sterilise carcases has shown a clear benefit.
- Further work is required to further validate the effectiveness of UV light application to decrease total viable count.

10.0 Project outputs

This project was able to determine the outcome of installing UV and ozone units within the FDC's of a lamb processing plant.

- The UV and ozone units were found to have no measurable impact on total fungal structures from air samples. It is recommended that larger UV and ozone units are installed.
- The UV unit installed to directly sanitise carcases at the end of the slaughter floor showed a measurable decrease in total viable count, removing spikes in this measure, increased shelf like by 8-10 days.