PPI

Opportunities for Improved Offal Recovery and their Validation. (Burst Cattle Paunches)

PIP.029

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August 2003

ISBN *1 74036 343 4*

AMPC

MEAT & LIVESTOCK AUSTRALIA

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Executive Summary

H.W. Greenham & Sons sought to undertake a validation trial to take advantage of recent research that demonstrated it is possible to salvage burst beef paunches without compromising food safety. In addition, the Project sought to identify opportunities to maximise the financial return on other offal products.

A workshop and validation trial were undertaken. The two-day workshop was held to skill staff on research into offal recovery opportunities, identify losses, calculate the financial opportunities and prioritise action for improvement. Sixteen Greenham Staff attended the Offal Yield Improvement workshop on August 17 2002. Key outcomes included:

- Tracking offal was the biggest single issue at the Tongala plant.
- It is essential to allow operatives to contribute to the improvement process.
- The incidence of dropped tails needs to be reduced.
- The correct method of hanging of tongues needs to be employed.

The validation trial tested the null hypothesis that:

1. The microbiological counts of scalded rumen tripe from burst paunches did not differ from those of intact paunches; and
2. The microbiological counts of unscalded rumen pillars from burst paunches did not differ provided that the same sampling techniques were followed. A total of 200 samples were collected for analysis of Standard Plate Count (SPC), Coliforms and *E.coli*. All pathogen analyses were acceptable. The only difference of significance related to total counts for tripe for "all data" and for samples from "Room 1". However, the difference was not meaningful given that the counts overall were very low. Data were also compared with data from the offal.com project. Tripe SPC counts from the Tongala Plant were much lower than those reported in the offal.com project.

Alternative procedures for collecting burst paunches were devised to enable H.W. Greenham & Sons to further comply with the AQIS Meat Notice 2001 / 21 "Enhanced Recovery of Green Offals at Exporting Slaughtering Establishments". Only small amendments to existing work instructions were required.

H.W. Greenham & Sons have demonstrated equivalence to meet AQIS requirements and have shown that the pathological counts of rumen pillars and tripe from burst paunches do not differ from those of intact paunches. As such, it is recommended that H.W. Greenham & Sons be allowed to salvage beef paunches, subject to final AQIS inspection, for further processing.

This Project has also resulted in the following additional benefits to H.W. Greenham & Sons operations:

1. A reduction in the condemnation of beef paunches;
2. An increase in the financial returns from beef paunches; and
3. Identification of opportunities to maximise returns from other offal products.

1. Introduction

Recent work funded by Meat & Livestock Australia (MLA-Offal-com) and undertaken by the University of Queensland has scientifically demonstrated that it is possible to salvage burst beef paunches without compromising food safety.

H.W. Greenham & Sons sought to undertake a validation trial on plant to take advantage of this recent research. In addition H.W. Greenham & Sons sought to identify opportunities to maximise the financial return on other offal products through further research and innovation.

This report details the successful development and validation of enhanced recovery protocols for burst paunches at H.W. Greenham & Sons in order to demonstrate to AQIS compliance with Meat Notice 2001/21 " Enhanced Recovery of Green Offals at Export Slaughtering Establishments". In addition, it details opportunities to maximise the return of offal products.

2. Objectives

The objectives of this Project were:

- to undertake an offal recovery workshop with relevant staff to identify, from a cost benefit analysis, opportunities for research into offal products based on their potential for increased recovery;
- to skill relevant staff to undertake research into offal recovery and to implement identified improvement processes;
- to specifically identify the current losses at H.W. Greenham & Sons during beef paunch recovery;
- to develop procedures for the collection of beef burst paunches for inclusion within the company's Meat Safety Quality Assurance (MSQA);
- to conduct a validation trial to confirm that the new offal recovery procedures meet microbiological food safety hazards at a level consistent with industry or benchmark standards; and
- to prepare a report on the outcome of the validation trial for presentation to Australian Quarantine and Inspection Service (AQIS).

3. Methodology

3.1 Workshop

A two-day workshop was held to skill staff on research into offal recovery opportunities, identify losses, calculate the financial opportunities and prioritise action for improvement. A spreadsheet program was provided to allow staff to easily identify losses and calculate gross margins for offal recovery.

3.2 Alternative Procedure For Collecting Burst Paunches

Re-evaluation of H.W. Greenham & Sons HACCP procedures were required to ensure the procedures required to recover burst paunches are validated and that every endeavour is made to demonstrate a reduction in the incidence of burst paunches over time. Full procedures (monitoring, corrective action and action limits) for controlling the contamination risk to carcases, green and red offals need to be reached and implemented.

3.3 Validation Of Alternative Procedures

To confirm the new procedures and demonstrate equivalence to meet AQIS requirements a validation trial was required. The null hypotheses of the trial were that

The microbiological counts of scalded rumen tripe from burst paunches do not differ from those of intact paunches.

The microbiological counts of unscalded rumen pillars from burst paunches do not differ from those of intact paunches.

Technical assistance from Alliance Consulting & Management (Alliance) ensured adequate sampling techniques were followed. A sampling protocol was devised as follows, and samples submitted to a NATA accredited laboratory for analysis (Symbio Laboratories, East Brisbane QLD). A total of 200 samples were collected for analysis. The sampling plan for the validation is provided in Annex 1.

3.3.1 Sampling of Tripe

- Five samples each of scalded tripe from burst paunches and intact paunches were collected immediately before packing on a daily basis for three consecutive days (morning and afternoon) from each of the two rooms processing paunches over a two week period.

- For each sample approximately 200 grams of tripe was removed aseptically and placed in a sterile plastic bag.

- All plastic bags were sealed and placed in an insulated container with refrigerated cooler bricks.

3.3.2 Sampling of Rumen Pillars

- Five samples each of Rumen Pillars from burst paunches and intact paunches were collected immediately before packing on three different days (morning and afternoon) from each of the two rooms processing paunches over a two week period.

- For each sample approximately 200 grams of Rumen Pillars was removed aseptically and placed in a sterile plastic bag.

- All plastic bags were sealed and placed in an insulated container with refrigerated cooler bricks.

Samples were sent to Symbio Laboratories for analysis of Standard Plate Count (method M2.1 reference AS1766.1.3 – 1991), Coliforms (method M8.8 reference AOAC 991.14) and *E. coli* (method M8.8, reference AOAC 991.14).

All data was analysed by Alliance Consulting & Management for statistical significance after conversion of microbial counts to their respective $\log_{10}$ values, and two sample t-tests (assuming equal variances) were performed to evaluate microbiological differences between burst and intact paunches for Standard Plate Count, Coliforms and *E. coli*. Where microbes were not detected they were given the value of 1 cfu to enable a $\log_{10}$ value to be determined (ie'0'). Because of the high occurrence of non-detections, the frequency of occurrence of coliforms and *E.coli* was examined between treatment groups using Chi^2 ananlysis.

4. Results & Discussion

4.1 Workshop

Sixteen (16) Greenham Staff attended the Offal Yield Improvement workshop on August 17 2002, delivered by Alliance Consulting & Management and were issued with certificates of attendance. A list of those attending is provided in Annex 2.

The workshop covered the following areas:

- Importance of offal recovery:
  - importance of offal to your business;
  - calculating the gross margins; and
  - opportunity for improvement in offal yield;
- Maximising yield in offal recovery:
  - what factors influence yield in offal recovery?
- Offal microbiology:
  - microbes in general/major microbe groups;
- Factors affecting microbe growth;
- Pre-slaughter and slaughter handling procedures;
- Techniques for improving yield:
- Product descriptions:
  - points of specification/trimming to customer requirements;
- Chilling and freezing;
- Packaging of offal;
- Offal yield benchmark;
- Validation of current or alternative procedures;

Outcomes from the initial workshop and observations by Alliance Consulting & Management included:

- How offal is tracked is the biggest single issue at the Tongala Plant. While the existing system of counting the pieces provides a certain amount of information it only addresses the number of items lost or condemned. In essence, 100% of the items could be recovered without any yield difference due to incorrect trim of cutting lines being known. To improve this situation, it was recommended that recovery weights be benchmarked against the tables supplied in the workbook, which expresses the weight of each item as a percentage of carcase weights. Once benchmark percentages are established then calculate total weights of each item recovered for a shift or day.

- It is essential to allow operatives to contribute to the improvement process. An example of this was the suggestion by one of the participants during the workshop to aggregate part cartons of cheek meat from the two chains at the end of each shift.

- The incidence of dropped tails needs to be reduced with the interim solution being for the operative to take as much care as time restraints allow, however ongoing consultation with all personnel involved needs to identify how the process can be improved.

- The correct method of hanging of tongues needs to be employed by both chains. One chain was pushing the draining hook right through the blade of the tongue resulting in damage to each tongue. While this is not an issue for the current customer, some high quality markets will object.

4.2 Alternative Procedure For Collecting Burst Paunches

H.W. Greenham & Sons have re-evaluated their HACCP plan, paying particular attention to:

- Identification and separation of carcases potentially contaminated due to a burst paunch using a tagging system.

- The probable difference in burst rates for different classes of stock and the implications for managing contamination.

- The separation of red offals from other offals to ensure red offals are not contaminated.

- The presentation of all offals to AQIS inspectors to ensure that the contaminated paunches do not represent a risk to other uncontaminated product as a result of the required inspection procedures.

- The removal of edible green offal from the viscera barrow to ensure cross contamination of edible offal is prevented.

- The operational hygiene and cleaning of the viscera barrow.

Most of the issues were already covered in existing work instructions. Revised (WI-11.2.2.8) and existing (WI-11.2.2.7) work instructions covering burst paunch requirements are attached (Annex 3).

4.3 Validation

A total of 200 samples were collected for analysis using the sampling protocol detailed in 3.3. Tripe and Pillar products were collected in Room 1 and Room 2 on three different days during the morning and afternoon shifts. Detailed microbiological results are provided in Annex 1. The following analyses were undertaken:

1. All data from Room 1 and Room 2 (tripe)
2. All data from Room 1 and Room 2 (pillars)
3. Data from Room 1 (tripe)
4. Data from Room 1 (pillars)
5. Data from Room 2 (tripe)
6. Data from Room 2 (pillars)

The frequency of occurrence of pathogens as indicated by *E.coli* did not differ significantly between treatments (Table 1).

Table 1: Frequency of occurrence of E.coli on processed burst paunches compared with numbers on intact paunches by offal room

***E.coli* (log$_{10}$ cfu/g)**	**Intact**	**Burst**
Room 1 - Tripe		
Not detected	32	40
0.01 – 1.00	0	8
1.01 – 2.00	48	36
2.01+	20	16
TOTAL	*100*	*100*
Room 2 – Pillars		
Not detected	12	20
0.01 – 1.00	4	4
1.01 – 2.00	32	32
2.01+	52	44
TOTAL	*100*	*100*
***E.coli* (log$_{10}$ cfu/g)**	**Intact**	**Burst**
Room 2 - Tripe		
Not detected	100	92.0
0.01 – 1.00	0	4.0
1.01 – 2.00	0	4.0
2.01+	0	0
TOTAL	*100*	*100*
Room 2 – Pillars		
Not detected	20.0	36.0
0.01 – 1.00	8.0	0
1.01 – 2.00	40.0	36.0
2.01+	32.0	28.0
TOTAL	*100*	*100*

Differences in the mean microbial counts between treatment groups are provided in Tables 2 – 4 for all data (Table 2), Room 1 (Table 3) and Room 3 (Table 4).

Table 2: Mean numbers of bacteria on processed burst paunches compared with numbers on intact paunches (all data)

	Intact (log_{10} cfu/g)	**Burst (log_{10} cfu/g)**	**Significance**
Total Bacteria (SPC)			
Tripe	2.96	3.21	P<0.05
Pillars	3.62	3.62	ns*
Coliforms			
Tripe	0.65	0.65	ns
Pillars	1.94	1.71	ns
E.coli			
Tripe	0.59	0.57	ns
Pillars	1.88	1.70	ns

Table 3: Mean numbers of bacteria on processed burst paunches compared with numbers on intact paunches (Room 1)

	Intact (log_{10} cfu/g)	**Burst (log_{10} cfu/g)**	**Significance**
Total Bacteria (SPC)			
Tripe	2.94	3.21	P<0.05
Pillars	3.65	3.76	ns
Coliforms			
Tripe	1.19	1.13	ns
Pillars	2.24	2.14	ns
E.coli			
Tripe	1.19	1.05	ns
Pillars	2.21	2.13	ns

Table 4: Mean numbers of bacteria on processed burst paunches compared with numbers on intact paunches (Room 2)

	Intact (log_{10} cfu/g)	**Burst (log_{10} cfu/g)**	**Significance**
Total Bacteria (SPC)			
Tripe	2.97	3.21	ns
Pillars	3.59	3.47	ns
Coliforms			
Tripe	0.11	0.18	ns
Pillars	1.64	1.28	ns
E.coli			
Tripe	0.00	0.09	ns
Pillars	1.54	1.26	ns

All pathogen analyses were acceptable. The only difference of significance related to total microbial counts for tripe for "all data" and for "Room 1". However, the difference is not meaningful given that the mean counts between treatment groups only differed by 0.25 and 0.26 log respectively. Data were also compared with data from the offal.com project. Tripe SPC counts from the Tongala Plant were much lower than those reported in the offal.com project (Table 5).

Table 5:Comparison of SPC counts for tripe – Tongala vs Offal.com

Tripe	Tongala – all data SPC (log_{10} CFU/g)	Offal.com project APC (log_{10} CFU/cm^2)
Baseline	2.96	3.55
Burst paunch	3.21	3.55

5. Conclusions & Recommendations

H.W. Greenham & Sons have demonstrated equivalence to meet AQIS requirements by this validation trial and has showed that the pathological counts of rumen pillars and tripe from burst paunches do not differ from those of intact paunches.

Given this result, it is recommended that H.W. Greenham & Sons be allowed to salvage beef paunches, subject to final AQIS inspection, for processing.

This Project has resulted in the following benefits to H.W. Greenham & Sons operations:

1. A reduction in the condemnation of beef paunches;
2. An increase in the financial returns from beef paunches; and
3. Identification of opportunities to maximise returns from other offal products.

6. References

AQIS Meat Notice 2001/12 Enhanced Recovery of Green Offals at Export Slaughtering Establishments, Department of Agriculture, Fisheries and Forestry – Australia.

Freund, J.E., (1984) Modern Elementary Statistics Sixth Edition, Published by Prentice-Hall Inc, ISBN 0-13-593559-8.

The Fifth Quarter (September 2001), Meat & Livestock Australia Co-Products Newsletter.

ANNEX 1 Validation Results

Table A1: Project Sampling Plan

Day	SAMPLE	ROOM 1				ROOM 2			
		Tripe (Honeycomb)		Pillars (Mountain Chain)		Tripe (Honeycomb)		Pillars (Mountain Chain)	
		Burst	Intact	Burst	Intact	Burst	Intact	Burst	Intact
1 (p.m.)	1	BH11	IH11	BM11	IM11	BH21	IH21	BM21	IM21
	2	BH12	IH12	BM12	IM12	BH22	IH22	BM22	IM22
	3	BH13	IH13	BM13	IM13	BH23	IH23	BM23	IM23
	4	BH14	IH14	BM14	IM14	BH24	IH24	BM24	IM24
	5	BH15	IH15	BM15	IM15	BH25	IH25	BM25	IM25
2 (a.m.)	1	BH16	IH16	BM16	IM16	BH26	IH26	BM26	IM26
	2	BH17	IH17	BM17	IM17	BH27	IH27	BM27	IM27
	3	BH18	IH18	BM18	IM18	BH28	IH28	BM28	IM28
	4	BH19	IH19	BM19	IM19	BH29	IH29	BM29	IM29
	5	BH110	IH110	BM110	IM110	BH210	IH210	BM210	IM210
2 (p.m.)	1	BH111	IH111	BM111	IM111	BH211	IH211	BM211	IM211
	2	BH112	IH112	BM112	IM112	BH212	IH212	BM212	IM212
	3	BH113	IH113	BM113	IM113	BH213	IH213	BM213	IM213
	4	BH114	IH114	BM114	IM114	BH214	IH214	BM214	IM214
	5	BH115	IH115	BM115	IM115	BH215	IH215	BM215	IM215
3 (a.m.)	1	BH116	IH116	BM116	IM116	BH216	IH216	BM216	IM216
	2	BH117	IH117	BM117	IM117	BH217	IH217	BM217	IM217
	3	BH118	IH118	BM118	IM118	BH218	IH218	BM218	IM218
	4	BH119	IH119	BM119	IM119	BH219	IH219	BM219	IM219
	5	BH120	IH120	BM120	IM120	BH220	IH220	BM220	IM220
3 (p.m.)	1	BH121	IH121	BM121	IM121	BH221	IH221	BM221	IM221
	2	BH122	IH122	BM122	IM122	BH222	IH222	BM222	IM222
	3	BH123	IH123	BM123	IM123	BH223	IH223	BM223	IM223
	4	BH124	IH124	BM124	IM124	BH224	IH224	BM224	IM224
	5	BH125	IH125	BM125	IM125	BH225	IH225	BM225	IM225

Table A2: Microbiological Results from Room 1

Day	Product	Sample	Burst/Intact	Sample Code	Standard Plate Count (CFU/g)	Coliforms (CFU/g)	E. coli (CFU/g)
Day 1 (am)	Tripe	1	Burst	BH11	530	35	35
		2	Burst	BH12	2900	40	35
		3	Burst	BH13	2100	80	80
		4	Burst	BH14	680	10	10
		5	Burst	BH15	1300	25	25
		1	Intact	IH11	1600	220	220
		2	Intact	IH12	2000	180	180
		3	Intact	IH13	780	45	45
		4	Intact	IH14	1200	75	75
		5	Intact	IH15	2800	220	220
Day 1 (am)	Pillar	1	Burst	BM11	76000	20000	20000
		2	Burst	BM12	120000	56000	56000
		3	Burst	BM13	60000	14000	14000
		4	Burst	BM14	5000000	250000	250000
		5	Burst	BM15	27000	6800	5800
		1	Intact	IM11	3000	660	650
		2	Intact	IM12	21000	2300	2300
		3	Intact	IM13	24000	10000	10000
		4	Intact	IM14	56000	22000	22000
		5	Intact	IM15	24000	8500	8500
Day 2 (am)	Tripe	1	Burst	BH16	860	240	240
		2	Burst	BH17	1400	90	90
		3	Burst	BH18	2800	620	620
		4	Burst	BH19	1600	0	0
		5	Burst	BH110	4300	0	0
		1	Intact	IH16	1400	55	55
		2	Intact	IH17	820	20	20
		3	Intact	IH18	840	25	25
		4	Intact	IH19	1400	35	35
		5	Intact	IH110	450	20	20
2 (am)	Pillar	1	Burst	BM16	2900	10	10
		2	Burst	BM17	1900	25	25
		3	Burst	BM18	67000	20	20
		4	Burst	BM19	120000	52000	52000
		5	Burst	BM110	2100	0	0
		1	Intact	IM16	56000	100	100
		2	Intact	IM17	7000	2000	2000
		3	Intact	IM18	18000	90	90
		4	Intact	IM19	3700	280	280
		5	Intact	IM110	1000	130	130
2 (pm)	Tripe	1	Burst	BH111	1300	0	0
		2	Burst	BH112	200	0	0
		3	Burst	BH113	1300	340	320
		4	Burst	BH114	20000	0	0
		5	Burst	BH115	3600	30	30
		1	Intact	IH111	400	0	0
		2	Intact	IH112	1100	35	30
		3	Intact	IH113	230	0	0
		4	Intact	IH114	2200	25	25
		5	Intact	IH115	420	0	0

Day	Product	Sample	Burst/Intact	Sample Code	Standard Plate Count (CFU/g)	Coliforms (CFU/g)	E. coli (CFU/g)
2 (pm)	Pillar	1	Burst	BM111	5500	25	25
		2	Burst	BM112	400	0	0
		3	Burst	BM113	860	0	0
		4	Burst	BM114	770	0	0
		5	Burst	BM115	4400	65	65
		1	Intact	IM111	250	0	0
		2	Intact	IM112	1400	30	30
		3	Intact	IM113	5700	20	20
		4	Intact	IM114	4400	170	45
		5	Intact	IM115	3400	95	95
3 (am)	Tripe	1	Burst	BH116	1000	15	10
		2	Burst	BH117	4400	20	15
		3	Burst	BH118	7100	20	0
		4	Burst	BH119	6800	40	30
		5	Burst	BH120	4400	320	320
		1	Intact	IH116	3100	500	500
		2	Intact	IH117	1700	120	120
		3	Intact	IH118	300	20	20
		4	Intact	IH119	6500	15	15
		5	Intact	IH120	480	60	60
3 (am)	Pillar	1	Burst	BM116	9600	1000	1000
		2	Burst	BM117	1100	50	50
		3	Burst	BM118	2400	220	200
		4	Burst	BM119	1200	25	25
		5	Burst	BM120	4200	430	360
		1	Intact	IM116	14000	4600	4600
		2	Intact	IM117	8800	360	360
		3	Intact	IM118	3600	55	55
		4	Intact	IM119	6400	880	880
		5	Intact	IM120	5000	230	230
3 (pm)	Tripe	1	Burst	BH121	800	0	0
		2	Burst	BH122	1300	55	45
		3	Burst	BH123	360	0	0
		4	Burst	BH124	1000	0	0
		5	Burst	BH125	260	0	0
		1	Intact	IH121	1400	0	0
		2	Intact	IH122	490	0	0
		3	Intact	IH123	420	0	0
		4	Intact	IH124	350	0	0
		5	Intact	IH125	140	0	0
3 (am)	Pillar	1	Burst	BM121	4600	320	310
		2	Burst	BM122	450	0	0
		3	Burst	BM123	670	40	35
		4	Burst	BM124	2500	80	80
		5	Burst	BM125	490	220	220
		1	Intact	IM121	680	60	60
		2	Intact	IM122	3700	0	0
		3	Intact	IM123	2100	420	420
		4	Intact	IM124	850	10	10
		5	Intact	IM125	180	0	0

Table A2: Microbiological Results from Room 2

Day	Product	Sample	Burst/Intact	Sample Code	Standard Plate Count (CFU/g)	Coliforms (CFU/g)	E. coli (CFU/g)
Day 1 (am)	Tripe	1	Burst	BH21	190	10	10
		2	Burst	BH22	2200	0	0
		3	Burst	BH23	310	10	0
		4	Burst	BH24	5800	0	0
		5	Burst	BH25	340	0	0
		1	Intact	IH21	250	0	0
		2	Intact	IH22	190	0	0
		3	Intact	IH23	620	0	0
		4	Intact	IH24	910	0	0
		5	Intact	IH25	250	0	0
Day 1 (am)	Pillar	1	Burst	BM21	14000	320	320
		2	Burst	BM22	1000	140	130
		3	Burst	BM23	2400	0	0
		4	Burst	BM24	5600	180	180
		5	Burst	BM25	12000	20	15
		1	Intact	IM21	1100	25	20
		2	Intact	IM22	4900	70	65
		3	Intact	IM23	4000	90	90
		4	Intact	IM24	600000	2400	2400
		5	Intact	IM25	84000	200	200
Day 2 (am)	Tripe	1	Burst	BH26	420	0	0
		2	Burst	BH27	120	0	0
		3	Burst	BH28	200	0	0
		4	Burst	BH29	1200	20	15
		5	Burst	BH210	140	0	0
		1	Intact	IH26	920	0	0
		2	Intact	IH27	810	0	0
		3	Intact	IH28	230	0	0
		4	Intact	IH29	640	0	0
		5	Intact	IH210	500	0	0
2 (am)	Pillar	1	Burst	BM26	31000	15000	15000
		2	Burst	BM27	1800	55	55
		3	Burst	BM28	1200	50	50
		4	Burst	BM29	38000	120	120
		5	Burst	BM210	30000	280	170
		1	Intact	IM26	20000	670	670
		2	Intact	IM27	47000	760	740
		3	Intact	IM28	37000	190	190
		4	Intact	IM29	110000	140	140
		5	Intact	IM210	1700	50	30
2 (pm)	Tripe	1	Burst	BH211	5400	0	0
		2	Burst	BH212	4300	0	0
		3	Burst	BH213	1600	0	0
		4	Burst	BH214	34000	0	0
		5	Burst	BH215	3000	0	0
		1	Intact	IH211	420	0	0
		2	Intact	IH212	100	0	0
		3	Intact	IH213	520	0	0
		4	Intact	IH214	1400	0	0
		5	Intact	IH215	5300	0	0

2 (pm)	Pillar	1	Burst	BM211	4400	40	40
		2	Burst	BM212	1300	0	0
		3	Burst	BM213	10000	360	300
		4	Burst	BM214	10000	0	0
		5	Burst	BM215	5500	110	100
		1	Intact	IM211	560	0	0
		2	Intact	IM212	1600	45	0
		3	Intact	IM213	500	0	0
		4	Intact	IM214	330	0	0
		5	Intact	IM215	600	55	45
3 (am)	Tripe	1	Burst	BH216	86000	15	0
		2	Burst	BH217	1500	0	0
		3	Burst	BH218	2100	0	0
		4	Burst	BH219	960	0	0
		5	Burst	BH220	1500	0	0
		1	Intact	IH216	3000	0	0
		2	Intact	IH217	3400	0	0
		3	Intact	IH218	58000	40	0
		4	Intact	IH219	2500	0	0
		5	Intact	IH220	440	0	0
3 (am)	Pillar	1	Burst	BM216	1900	0	0
		2	Burst	BM217	300	0	0
		3	Burst	BM218	960	0	0
		4	Burst	BM219	1800	25	25
		5	Burst	BM220	320	0	0
		1	Intact	IM216	3800	10	10
		2	Intact	IM217	5000	1500	490
		3	Intact	IM218	1400	15	15
		4	Intact	IM219	43000	680	660
		5	Intact	IM220	3600	40	40
3 (pm)	Tripe	1	Burst	BH221	2200	0	0
		2	Burst	BH222	2300	0	0
		3	Burst	BH223	670	0	0
		4	Burst	BH224	4400	0	0
		5	Burst	BH225	19000	0	0
		1	Intact	IH221	4600	0	0
		2	Intact	IH222	12000	15	0
		3	Intact	IH223	410	0	0
		4	Intact	IH224	360	0	0
		5	Intact	IH225	590	0	0
3 (am)	Pillar	1	Burst	BM221	1200	0	0
		2	Burst	BM222	1300	40	40
		3	Burst	BM223	2000	15	15
		4	Burst	BM224	520	0	0
		5	Burst	BM225	2200	20	20
		1	Intact	IM221	710	15	15
		2	Intact	IM222	540	10	10
		3	Intact	IM223	690	0	0
		4	Intact	IM224	1400	35	35
		5	Intact	IM225	590	30	30

Table A3: T-test Results "All data"

Product	Log10SPU				Log10Coliform				Log10E.coli			
	t	df	sig. (2-tailed)	Mean difference	t	df	sig. (2-tailed)	Mean difference	t	df	sig. (2-tailed)	Mean difference
Tripe	-2.237	98	0.028	-0.2527	-0.02	98	0.984	-0.0036	0.135	98	0.893	0.0235
Pillars	0.031	98	0.976	0.0049	0.883	98	0.380	0.2301	0.692	98	0.491	.1715

Table A4: T-test Results "Room 1"

Product	Log10SPU				Log10Coliform				Log10E.coli			
	t	df	sig. (2-tailed)	Mean difference	t	df	sig. (2-tailed)	Mean difference	t	df	sig. (2-tailed)	Mean difference
Tripe	-2.152	48	0.036	-0.2658	0.230	48	0.819	0.0608	0.502	48	0.618	0.1341
Pillars	-0.456	48	0.650	-0.1088	0.241	48	0.810	0.0978	0.209	48	0.835	0.0849

Table A5: T-test Results "Room 2"

Product	Log10SPU				Log10Coliform				Log10E.coli			
	t	df	sig. (2-tailed)	Mean difference	t	df	sig. (2-tailed)	Mean difference	t	df	sig. (2-tailed)	Mean difference
Tripe	-1.248	48	0.218	-0.2395	-0.592	48	0.557	-0.0680	-1.440	48	0.156	-0.0870
Pillars	0.552	48	0.584	0.1186	1.205	48	0.234	0.3624	0.921	48	0.362	0.2781