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Hazard Analysis and Critical Control Point (HACCP) and Hygiene Auditing in Irish Beef Abattoirs

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HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) AND HYGIENE AUDITING IN IRISH BEEF ABATTOIRS

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SUMMARY

This project validated two innovative technologies for use in improving the safety of Irish beef. Online monitoring was developed and successfully tested as a tool for controlling faecal contamination on beef carcasses with the resultant reduction in microbial counts. A novel anti-microbial, LactiSAL®, was also tested and validated for use in the beef industry.
Sponge swabbing using a polyurethane sponge was developed and validated for use in carcass testing as required in European Commission Decision 2001/471/EC. The costs of developing and implementing a HACCP system in Irish beef slaughter plants were assessed. Furthermore, a guide to relevant food safety legislation, including the development and auditing of HACCP and prerequisites for beef slaughter (in compliance with 2001/471/EC and the European Commission Hygiene Regulations), was developed and published.

INTRODUCTION

Beef is an important source of bacterial pathogens such as *Salmonella* Typhimurium DT104 and *Escherichia coli* O157:H7. Beef slaughter plants have a legal and moral obligation to develop and implement prerequisite and HACCP food safety programmes to minimise the risk of their products acting as a vehicle of transmission for zoonotic agents. This project has delivered a layman's guide to beef slaughter prerequisites and HACCP.

The prerequisites and HACCP should be scientifically-based and achieve the required microbiological criteria set out in current food safety legislation. This project developed and/or validated two novel technologies to assure compliance with 2001/471/EC (Anon, 2001); these technologies will also decrease the risk of contamination with pathogens such as *Salmonella* Typhimurium DT104 and *Escherichia coli* O157:H7.

With tight profit margins, cost is an important consideration in the development and operation of beef slaughter prerequisites and HACCP. This

project undertook a survey of the costs associated with these food safety programmes, facilitating budgeting for such developments.

Testing to demonstrate compliance with microbiological criteria contained in the 2001/471/EC and Hygiene Regulations should allow for carcass sampling methods that are cheap, convenient and non-destructive. This project delivered a polyurethane sponge-based method favoured by the Irish beef industry.

VALIDATION STUDIES ON AN ONLINE MONITORING SYSTEM FOR REDUCING FAECAL AND MICROBIAL CONTAMINATION ON BEEF CARCASSES

The objective of this research was to validate an online monitoring technology for recording the incidence of faecal contamination on beef carcasses and identifying causative operations thereby permitting corrective action.

On 22 separate visits over the course of 6 months, approximately 500 carcasses per visit were examined at the final inspection stand for visible faecal contamination; these included 4 visits before the implementation of the online monitoring system (denoted with a minus sign in Figure 1 below). During each visit, ten carcasses were swabbed at the final inspection stand (immediately before trimming) at the anus, rump, brisket, flank and on the hock. Sampling times were spread approximately evenly over the course of a day's production. Swabbing was performed using a polyurethane sponge (Churchill and Sons Ltd., Basingstoke, UK), previously tested to ensure it had no anti-microbial properties, cut to a size of 10cm x 10cm, wrapped in greaseproof paper and sterilised by autoclaving at 121°C for 20 minutes at 15 lb per square inch pressure. Immediately before use, each sponge was aseptically transferred to an individual stomacher bag and moistened with approximately 5ml of sterile maximal recovery diluent (MRD; Oxoid, Basingstoke, UK.). At the sampling point, the operative gripped the moistened sponge through the bottom of the bag and inverted the upper parts of the bag over the wrist and forearm thus ensuring that only the carcass came in contact

with the sterile sponge. An area of 100cm^2, delineated by a sterile metal template, was swabbed at each of the carcass sites. All the swabbing was performed by the same individual and included 5 horizontal, 5 vertical and 5 diagonal swabs within the 100cm^2 area. The bag was then inverted and the sponge transported to the laboratory in a cooler box with ice blocks to ensure a transport temperature of approximately 4°C.

In the laboratory, 100ml of MRD was added to each bag containing a sponge and stomached using a Colworth stomacher set at medium for 2 minutes. From the resultant mixture, a serial dilution was prepared using MRD. TVCs were obtained by duplicate spread plating 0.1 ml of the MRD suspensions onto standard plate count agar (Oxoid); plates were incubated at 25°C for 72 hours. *E. coli* counts (ECC) and total coliform counts (TCC) were obtained by duplicate plating of 0.1ml of MRD suspensions onto Chromocult Coliform agar (Merck, 64271, Darmstadt, Germany) with plates being incubated at 37°C for 24 hours. Total *Enterobacteriaceae* counts (TEC) were obtained by preparing duplicate VRBGA (Oxoid) pour plates using 1 ml of MRD suspensions. Plates were over-poured with VRBGA to create a semi-aerobic environment and incubated at 37°C for 24 hours.

The incidence of faecal contamination on each carcass was monitored by visibly inspecting every carcass side (immediately before trimming) produced on the day of microbiological sampling and recording the results using a modification of the information technology-based monitoring system described by Bolton *et al.* (1999). This system consisted of four push-buttons linked to a PC and a photo-eye which counted the total number of carcasses processed. Each faecal contamination event was recorded on the PC by pushing a colour-coded push-button, corresponding to a different area on the carcass. Each event was then ascribed by a trained operator to either the dehiding or evisceration operations and expressed as a percentage contamination rate for each of these operations by dividing the number of hits by the total number of carcasses processed. The contamination data was reviewed with the plant management on a fortnightly basis and a variety of

corrective actions, including retraining/replacing personnel, increased supervision, replacement of knives, steels and scabbards, etc. and the checking of sterilisers, was undertaken.

Mean bacterial counts (the mean count per carcass site) for each visit were obtained from the sum of the log counts obtained at each site per carcass. Analysis of variance was performed using Genstat 5 (Statistics Department, Rothamsted Experimental Station, Hertfordshire, UK). Regression analysis was performed using *GraphPad Instat* (version 3).

Over the course of this study, faecal contamination rates for dehiding and evisceration were reduced from 54.2% to 28.2% and from 32.5% to 13.7%, respectively. TVC remained constant at approximately 3.0 $\log_{10}$ cfu cm^{-2} while ECC, TEC and TCC decreased by 0.84 $\log_{10}$ cfu cm^{-2}, 0.35 $\log_{10}$ cfu cm^{-2} and 0.79 $\log_{10}$ cfu cm^{-2} respectively (Figure 1). Online monitoring is therefore an effective means of reducing the incidence of bovine carcass faecal contamination and enteric counts on beef carcasses.

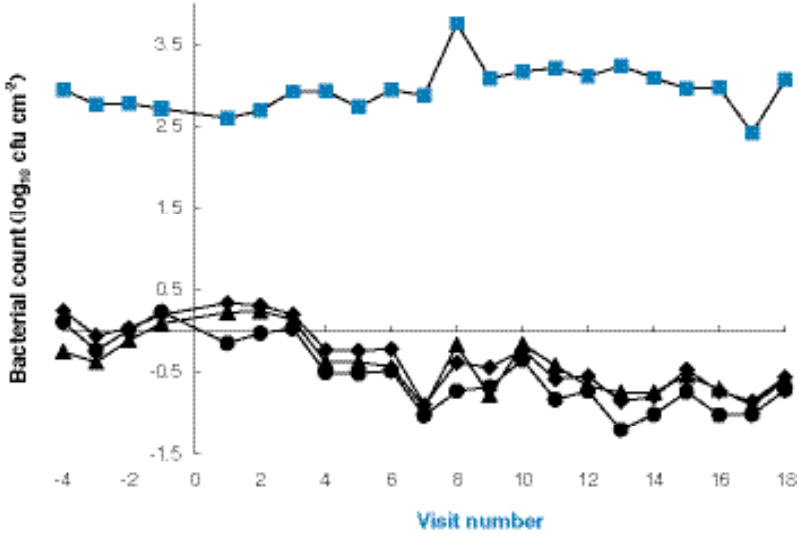

Figure 1. The mean TVC (■), ECC (●), TEC (▲) and TCC (◆) obtained on the bovine carcasses over the course of the study.

AN INVESTIGATION OF THE ANTI-MICROBIAL EFFECT OF A DAIRY EXTRACT (LACTISAL®) ON *SALMONELLA ENTERICA* TYPHIMURIUM AND *ESCHERICHIA COLI* O157:H7 ON DIFFERENT BEEF CARCASS SURFACES

The aim of this study was to evaluate the anti-microbial effectiveness of a dairy extract (LactiSAL®) against *Salmonella enterica* Typhimurium and *Escherichia coli* O157:H7 attached to different beef carcass surfaces. Three beef carcass surface types were investigated in this study - fat, lean and cut surface. Samples were surface inoculated with 6 $\log_{10}$ cfu cm^{-2} of either *S.* Typhimurium or *E. coli* O157:H7 and left at room temperature for 30min to allow for bacterial attachment. Samples were then treated by spraying with the dairy extract (LactiSAL®) and sampling over a 3h period. The application of the novel dairy extract resulted in a considerable reduction in *S.* Typhimurium (Table 1) and in *E. coli* O157:H7 numbers (Table 2) on fat, lean and cut surfaces. The results of this study showed that LactiSAL® has great potential as a decontaminating agent and could be used to enhance the safety of beef carcasses. LactiSAL® is a cheap, safe, environmentally-friendly and effective anti-microbial carcass wash that will revolutionise beef carcass food safety and provide an efficient intervention critical control point (CCP) for beef slaughter HACCP.

Table 1: The effect of LactiSAL® extract on the survival of *S.* Typhimurium on fat, lean and cut beef surfaces

		Surface microbial numbers ($\log_{10}$ cfu cm^{-2})		
	Time	Fat	Lean	Cut
Untreated	0 min	5.92	6.06	6.22
	1 hr	6.04	5.87	6.14
	2 hr	5.80	5.96	6.25
	3 hr	5.68	6.02	6.14
Treated	0 min	1.22	ND	ND
	1 hr	1.83	ND	1.15
	2 hr	ND*	1.36	1.72
	3 hr	ND	ND	ND

*ND = not detected

Table 2: The effect of LactiSAL® on the survival of *E. coli* O157:H7 on fat, lean and cut beef surfaces

		Surface microbial numbers log_{10} cfu cm^{-2}		
	Time	Fat	Lean	Cut
Untreated	0 min	6.27	6.26	6.25
	1 hr	6.17	6.26	6.30
	2 hr	6.11	6.28	6.22
	3 hr	6.11	5.90	6.29
Treated	0 min	2.65	2.23	4.82
	1 hr	2.17	2.59	2.93
	2 hr	2.36	1.96	3.41
	3 hr	1.10	1.98	4.09

EXCISION *VERSUS* SPONGE SWABBING - A COMPARISON OF METHODS FOR THE MICROBIOLOGICAL SAMPLING OF BEEF, PORK AND LAMB CARCASSES

The aim of this research was to compare excision sampling with sponge swabbing (polyurethane and cellulose acetate sponge) for the recovery of total viable counts (TVCs) and *Enterobacteriaceae* on meat carcasses.

Individual samples were taken from four sites on each carcass and composite samples, created by pooling the samples from four sites, were obtained from an additional set of carcasses. When the polyurethane sponge and excision method were compared for individual sites, there were no significant differences in TVCs recovered on beef and pork carcasses and on 2 out of 4 sites on lamb carcasses (Table 3). However, when samples from each site were pooled, the excision method was more efficient than either swabbing method regardless of animal species (Table 4). In general, *Enterobacteriaceae* were recovered from a larger number of beef, pork and lamb carcasses when sampled by sponge swabbing as compared to excision for both individual and

pooled samples. However, *Enterobacteriaceae* were recovered infrequently and general relationships could not be established (data not shown).

This research suggests that polyurethane sponge swabbing was equivalent to excision for the bacteriological sampling of carcass surfaces and provides a scientific basis for using sponge swabbing instead of excision in compliance with 2001/471/EC.

Table 3: Comparison of total viable counts (TVCs) recovered by excision or sponge swabbing (polyurethane and cellulose acetate) from selected sites on 30 beef carcasses

Species / (Sampling site)	Excision	Sponge (polyurethane)	Sponge (cellulose acetate)	Degrees of freedom	SED*
			$\log_{10}$ cfu cm^{-2}		
Beef (rump)	2.5[a]*	2.2[a]	2.3[a]	81	0.22
Beef (flank)	2.1[a]	1.7[a]	1.9[a]	81	0.17
Beef (brisket)	2.3[a]	2.3[a]	2.2[a]	81	0.2
Beef (neck)	2.2[a]	1.9[a]	2.0[a]	81	0.2
Pork (ham)	2.9[a]	2.7[a]	2.0[b]	81	0.14
Pork (back)	3.1[a]	3.3[a]	2.6[b]	81	0.17
Pork (belly)	3.2[a]	3.1[a]	2.3[b]	81	0.15
Pork (jowl)	3.1[a]	3.1[a]	2.6[b]	81	0.14
Lamb (thorax)	3.4[a]	2.9[b]	2.7[b]	81	0.11
Lamb (shoulder/neck)	3.6[a]	2.8[b]	2.5[c]	81	0.12
Lamb (breast/brisket)	3.5[a]	3.3[a]	2.7[b]	81	0.15
Lamb (flank)	2.4[a]	2.5[a]	2.3[a]	81	0.15

*SED – standard error of the difference. **Note: The superscript letters indicate statistical difference within each animal species only. For example, none of those values denoted by the superscript 'a' are statistically different.

Table 4: Comparison of total viable counts (TVC) recovered by excision or sponge swabbing (polyurethane and cellulose acetate) from pooled samples on beef, pork and lamb carcasses

Species / Excision Sampling site	Sponge (polyurethane)	Sponge (cellulose acetate)	Degrees of freedom	SED*
	$\log_{10}$ cfu cm^{-2}			
Beef	2.4a*	1.9b	1.8b	81	0.12
Pork	3.4a	3.0b	2.5c	81	0.07
Lamb	3.3a	2.7b	2.4c	81	0.11

*SED – standard error of the difference. **Note: The superscript letters indicate statistical difference within each animal species only. For example, none of those values denoted by the superscript 'a' are statistically different.

AN ASSESSMENT OF COSTS ASSOCIATED WITH BEEF HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) DEVELOPMENT AND IMPLEMENTATION

The European Commission has introduced legislation legally mandating the implementation of hazard analysis and critical control point (HACCP) principles in all meat and poultry slaughter plants (Anon, 2001). In this Commission Decision (2001/471/EC) meat operators are required to apply the seven codex principles of HACCP as a tool to minimise or prevent food safety hazards. All operators of meat establishments are required to carry out regular checks on general hygiene conditions and to maintain a permanent procedure developed in accordance with HACCP principles. They are also required to carry out microbiological checks in accordance with the procedure laid down in the Annex of 2001/471/EC.

HACCP involves a systematic, scientific approach to process control, designed to prevent, reduce or eliminate identified hazards in food products and is generally accepted as the most effective means of minimising the levels of

contamination on many food products. While there are many benefits to HACCP, there are currently no data on the cost of developing and implementing such a system into beef plants. The objective of this study was therefore to assess the costs associated with developing and implementing HACCP in beef export abattoirs.

A cost survey was carried out in three stages. Firstly, a mail survey was sent to all 33 beef export plants in the Republic of Ireland. Two weeks later all participants were contacted by phone and given the opportunity to conduct the survey over the phone. Finally, after six weeks had elapsed, the mail survey was sent a second time to all those export plants which had not responded to the first mail survey. Data obtained was analysed using the Statistical Packages for the Social Sciences (SPSS).

The main findings of the survey were as follows:

- average cost of developing a HACCP plan was €28,379
- average HACCP training costs were €8,375 (external trainer) and €1,200 (internal trainer)
- average annual cost of operating a HACCP system was €275,775

DEVELOPMENT AND AUDITING OF PREREQUISITE PROGRAMMES AND HACCP PRINCIPLES FOR THE IRISH BEEF INDUSTRY

To prevent or minimise contamination during beef slaughter, all aspects of the slaughter process must be properly controlled; this control is achieved using food safety management programmes. Programmes fall into three categories: Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and Hazard Analysis and Critical Control Points (HACCP) programmes. HACCP is not a stand-alone programme and must be supported by a firm foundation of current GMP and GHP.

This project developed and published a set of documents (Figure 2) which provide a guide for the development and auditing of prerequisite programmes and HACCP principles for the Irish beef industry. These documents focus on Irish and European legislation and explain how compliance may be achieved.

Figure 2: Published guides for the development and auditing of prerequisite programmes and HACCP principles for the Irish beef industry.

CONCLUSIONS

The following conclusions were made as a result of the research undertaken in this project:

- Online monitoring technology is effective for controlling faecal contamination on beef carcasses and should be applied to improve carcass hygiene and reduce any potential food safety risk to a minimum.

- LactiSAL® is an effective carcass decontaminant and should be further tested under abattoir conditions as it has the potential to kill *S.*Typhimurium and *E. coli* O157, thereby protecting public health.

- The polyurethane sponge technology developed and validated in this project may be applied in carcass microbiological sampling as required in 2001/471/EC and the Hygiene Regulations which came into effect in January 2006.

- Results from studies reported in this document indicate that the average reported initial cost of developing a beef slaughter HACCP system for an export plant is €28,379 with an annual operating cost of €275,775.

RECOMMENDATIONS TO INDUSTRY

- Apply online monitoring technology to reduce the incidence of faecal contamination on beef carcasses.

- Consider using a polyurethane sponge swabbing method for sampling the carcasses instead of excision.

- Use the guidance documents; 'Development of prerequisite programmes and HACCP principles for Irish beef slaughterhouses' and 'Auditing of prerequisite programmes and HACCP principles for Irish beef slaughterhouses' when developing, reviewing and implementing beef slaughter prerequisite and HACCP programmes.

PUBLICATIONS

Pearce, R. and Bolton, D. J. (2004). Excision versus Sponge Swabbing - A Comparison of Methods for the Microbiological Sampling of Beef, Pork and Lamb Carcasses. *Journal of Applied Microbiology*, **98**(4), 896-900.

Tergny, A. and Bolton, D.J. (2004). Validation Studies on an Online Monitoring System for Reducing Faecal and Microbial Contamination on Beef Carcasses. *Food Control*, **17**(5), 378-382.

Pearce, R. and Bolton, D. J. (2006). An investigation of the anti-microbial effect of a dairy extract (LactiSAL®) on *Salmonella enterica* Typhimurium and *Escherichia coli* O157:H7 on different beef carcass surfaces. Submitted to *Food Control* (August 2006).

Howlett, B., Bolton, D. J. and O'Sullivan, C. (2005). Development of prerequisite programmes and HACCP principles for Irish beef slaughterhouses. Teagasc-The National Food Centre. ISBN 1 84170 393 1.

Howlett, B., Bolton, D. J. and O'Sullivan, C. (2005) Auditing of prerequisite programmes and HACCP principles for Irish beef slaughterhouses. Teagasc-The National Food Centre ISBN 1 84170 394 1.

REFERENCES

Anon. (2001) Commission Decision of 8 June 2001 (2001/471/EC). *Official Journal of European Communities*, **L165**, 48-53.

Bolton, D. J., Oser A. H., Cocoma, G. J., Palumbo, S. A. and Miller, A. (1999). Integrating HACCP and TQM reduces pork carcass contamination. *Food Technology*, **53**, 40–43.

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