REDUCTION OF FECAL CONTAMINATION AND BACTERIAL LEVELS ON PORK CARCASSES BY ON-LINE VISUAL MONITORING

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BACKGROUND: The U.S. implemented a requirement that no visible fecal material can be present on dressed meat animal carcasses. In U.S. pork establishments, contaminated material is trimmed using sanitized knives. This is a critical control point (CCP) in a generic HACCP model. HACCP systems can minimize microbial contamination on meat carcasses, thus decreasing human health risks. While monitoring should be conducted around CCP's to reduce hazards, real-time microbiological monitoring is beyond current technology. As a consequence, indirect measurements are necessary.

OBJECTIVES of this study were to test the hypothesis that integration of on-line monitoring, feedback to operators engaged in evisceration, cumulative record keeping, and microbiological verification can result in continuous process improvement to lower fecal contamination and bacterial indicator levels on pork carcasses.

METHODS: One hundred kg pigs were slaughtered at a rate of approximately 900 per hour (2), as outlined in Table 1, as are mechanical aspects of the monitoring system. Using sanitized knives, five operators visually detected and trimmed all fecal contamination and ingesta, then each event was attributed to one of three anatomical locations. By pressing a push button, corresponding to an area of contamination on the carcass, the trimmers alerted, by a loud alarm, the operators responsible for the contamination event (Table 2). In addition, a score was registered against that operation on an LED display board located within the visual field of the operator. A photo-eye tallied a daily total. The percentage of contaminated carcasses was calculated daily and displayed on the same LED display. Data were reviewed and tolerance breaches were investigated and solutions were implemented. Problems were attributed to one or more factors (Table 3). *Microbiological Analysis*: An area along the side of the belly was swabbed using a template and a sponge moistened with Butterfield's buffer, immediately after the final carcass washer and before chilling. After mixing in a Stomacher 400 Laboratory mixer and making dilutions as needed in Butterfield's buffer, the aerobic plate count was determined by pour plating with Standard Plate Count Agar. The plates were incubated aerobically at 35°C for 48 hours before manual counting.

RESULTS: Initially, carcass contamination decreased from 7.6% to 5.3% of all carcasses (Figure 1). However, two months into the test, contamination had reverted to 6.7%. The monitoring system identified the evisceration stage as being primarily responsible for this increase and an intensive training program was implemented. As a result, the total contamination rate decreased by approximately 3% within two months. Thereafter, the overall trend was downwards reaching 1.8% by November 1995, some 2.5 years after the system was first started. Despite a peak (3%) in February 1996, contamination continued to decrease, reaching an all time low of 1.08% in October 1997. Microbial data detailing the total aerobic bacteria, as colony forming units (cfu) per 2.54 cm^2 of the carcass, were obtained for the first two and a half years of the project. Microbial contamination decreased consistently from an initial count of 4.8 to 2 $\log_{10}$ cfu /2.54 cm^2 (Figure 2). Interestingly, analysis of these data showed a strong correlation (R^2 = 0.88) between visible carcass contamination and the total plate count, demonstrating the practical benefit of the online carcass monitoring system in improving the microbial quality of the hog carcasses.

DISCUSSION: Efficient evisceration depends upon several factors, including: the source of the hogs, feed withdrawal times, as well as the skills of individual operators and operator turnover. Indeed the techniques used to eviscerate determine the extent of contamination of the carcass with fecal matter and ingesta. Since intestines of healthy pigs contain human pathogens, viscera removal operations are a major source of these pathogens. Educating employees about the importance of a job is key to achieve the highest standards of performance. This is particularly important in the meat industry where high employee turnover rates prevail. In addition, employees need to be motivated, despite repeating the same task several thousand times per day. Integrating HACCP and Total Quality Management (TQM) provide the best approach to improve safety and quality in the food industry (1). The online carcass monitoring system is integrated into the company's HACCP program, and was used to apply TQM principles. Employee responsibility, participation, input and feedback motivate operators in critical areas to continually improve their performance.

CONCLUSIONS: An eight-fold reduction in carcass contamination rate has resulted, while microbial contamination levels decreased 99.8%. Indeed, implementation may decrease overall production costs, as less trimming results in the need for fewer personnel and less waste. This system should find application in other meat plants as an important tool in the drive to improve the microbial safety of meat products.

Table 1. Slaughter and dressing operation and location of hardware components used for the online swine carcass, fecal contamination monitoring system

Operation	Monitoring area number	Monitoring system components and location				
		LED Display	Push buttons	Photo eye	Computer	Controller/ reset
Holding						
Stunning						
Bleeding						
Scalding						
Dehairing						
Polishing						
Singeing						
Carcass washing						
Head removal						
Head inspection						
Debunging	1	✔				
Carcass opening	2	✔				
Evisceration	3	✔				
Carcass Splitting						
Trimming			✔*			
Stamping						
Weighing				✔		
Chilling						
Electronic controlling					✔	✔

*After trimming visible fecal contamination, the trimmer activates one of three push buttons (orange, yellow, blue) located at each trimming station, corresponding to monitoring area numbers 1,2, and 3, respectively. This activates an short alarm, and a contamination event is displayed on the LED located in view of the operators (see Table 2).

Table 2. Linkage between contamination location on carcasses and unit operation source.

Anatomical location of contamination	Monitoring area number	Unit operation likely to cause contamination	Push button color located at trimming stations
Ham/tenderloin	1	Debunging	Orange
Rib cage/leaf lard	2	Evisceration	Yellow
Breast bone	3	Carcass opening	Blue

Table 3. Causes of errors and corrective action taken if tolerances are exceeded

Contamination cause	Error	Corrective action
Personnel	Incorrect procedure	• Review procedure • Replace/rotate employee • Adjust work environment
Equipment	Failure	• Repair/adjust • Modify • Add equipment
Usual practices	Bloated intestine	• Collect data linking contamination with gut fill • Interact with producer • Review transport practices
Other factors	Unforseen	• Appropriate to correct

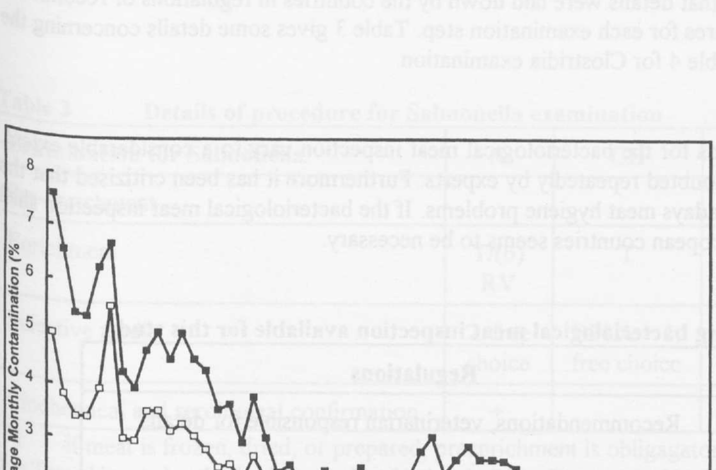

Figure 1. Average monthly percent carcasses contaminated (■), and individual contamination at areas, including: #1 (○; ham/tenderloin); #2 (Δ: rib cage/leaf lard), and #3 (□; breast bone), which make up this total.

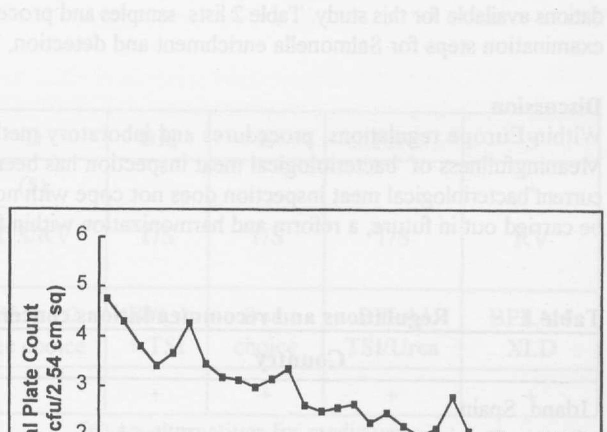

Figure 2. Average total plate count for 29 months