EVALUATION OF SPOILAGE MICROORGANISMS ON PORK CARCASSES DURING SLAUGHTER AND FABRICATION IN THREE U.S. PORK PACKING PLANTS

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SUMMARY

Bacterial contamination levels of pork carcasses were evaluated at four consecutive sites throughout the slaughter and fabrication processes of three typical U.S. pork plants. The sampling sites included: 1- after singeing and polishing, 2-after the final rinse on the slaughter floor, 3- after an 18-24 hour chill, 4- after fabrication, but before vacuum packaging. Pork carcasses and boneless loins were tested for five types of bacteria. The first sampling site (after singeing and polishing) established the initial contamination level for carcasses, however, bacterial counts either increased or decreased from that point, depending upon the type of bacteria. In the case of psychrotrophs and coliforms, counts decreased, as the carcasses left the slaughter floor and through the 18-24 hour chill, but increased again later during fabrication. Loins were found to be significantly ($P<0.05$) more contaminated by psychrotrophs and coliforms during the fabrication and cutting processes than the carcasses were at any other sampling site. In contrast, the anaerobic and aerobic mesophiles decreased in counts, from the first sampling site, on the slaughter floor to the point that the boneless loins were packaged. Assuming that psychrotrophic counts are the best indicator of chilled, vacuum packaged pork shelf life, the greatest contamination to fresh pork, prior to packaging, occurred in the cutting and fabrication areas of the plants studied.

INTRODUCTION

While it has been known for quite some time how contamination of pork carcasses occurs (Haines, 1933a; Ingram, 1949; Ayres, 1955), little research has been done in recent years, in high speed U.S. pork plants, on determining the amount of microorganisms on the pork carcass and identifying the main sources of this microbial contamination. Various researchers have reported that meat from healthy animals can be considered sterile at the time of slaughter and that the shelf life of meat depends on contamination from extrinsic bacteria (Gill, 1979). Numerous researchers have separated the slaughterhouse into "clean" and "unclean" areas (Ingram and Roberts, 1976; Gerats et al., 1981). Several European researchers have studied the effects of slaughter on the amount of contamination on pork carcasses (Ingram and Roberts, 1976; Gerats et al., 1981; Snijders, 1988). Others have suggested ways of extending the shelf life of fresh, chilled vacuum packaged pork using various organic acid rinses (Biemuller et al., 1973; Gerats et al., 1981; Snijders et al., 1985).

The purpose of this study was to determine during which of four broad points in the total slaughter and fabrication processes that microbial contamination of pork was greatest. The ultimate goal of this project is to identify the greatest source(s) of microbial contamination to pork carcass or primal cuts, during the slaughtering and/or fabrication in order to determine where changes need to be made that will ultimately extend the shelf life of fresh, chilled vacuum packaged pork for the export market.

MATERIALS AND METHODS

The plants selected were typical of modern, midwestern U.S. pork slaughtering plants, had comparable line speeds (approximately 960-1000 head/hour), and were involved in exporting fresh pork loins to Japan. The three plants were visited at random on three different occasions each, with microbiological testing being performed midweek, from June to early September, of 1991, to reduce the amount of daily variation in microbial contamination. Fifteen pork carcasses were selected, at random, at the same four sites in each of the plants. Sampling sites included: immediately after singeing and polishing; after the final rinse on the slaughter floor on Tuesdays; after an 18-24 hour period in the carcass coolers: and immediately prior to packaging. Each carcass was swabbed at the midpoint of the loin.

The sampling of the carcasses was done by using a moistened, sterile swab technique, on line, as carcasses passed by, so as to disrupt normal production as little as possible. The organisms targeted for were: psychrotrophs, coliforms, anaerobes (mesophilic), aerobes (mesophiles) and lactic acid bacteria.

The samples were then plated out in duplicate using standard methods for the five types of microorganisms. Coliforms were enumerated using Trypticase Soy Agar (TSA), with a double strength overlay of Violet Red Bile Agar (VRB) at 35°C for 48±2 hours. Total aerobic counts were determined by TSA agar, incubated at 30°C for 48±2 hours. Total anaerobes were enumerated on Brain Heart Infusion Agar (BHI), while the lactics were grown using lactobacillus-specific media (LBS) and both types of microorganisms were incubated at 30°C for 48±2 hours. Both the total anaerobes and the lactics were held in an anaerobic environment, attained by placing the plates in a sterile Nylon/PVDC/EVA laminate vacuum packaging bag (Curlon 862, Curwood, Inc.) and vacuum packaging them using a Model A300 vacuum packaging machine (CVP Systems, Inc.), followed by back-flushing with a gas mixture of 40% carbon dioxide (CO_2) and 60% nitrogen (N_2). Psychrotrophs were enumerated on TSA agar, incubated at 5°C for 10 days.

Bacterial counts were converted to logarithmic numbers, which were analyzed using the Statistical Analysis System (SAS Institute, Inc., 1986) according to General Linear Model (GLM) procedures. An analysis of variance with a split-plot experimental design, based on means, was used. The comparisons of means were made according to Least Significant Differences (LSD).

RESULTS AND DISCUSSION

A highly significant difference ($P<0.01$) was found for psychrotrophic counts, among sites within plants and sites among plants (Fig. 1, Table 1). However, it was found for all three plants that the greatest contamination was observed at the point of fabrication (Site 4), immediately prior to boneless loin packaging. In general, the psychrotrophic numbers declined significantly ($P<0.01$) after the singeing and polishing steps, but remained constant until the cutting and fabrication processes.

No significant ($P>005$) correlation was found between the final level of boneless loin contamination, and any of the following three sampling sites, including: after fabrication and cutting (Site 4), after singeing and polishing (Site 1), after the final rinse on the slaughter floor (Site 2), and after an 18-24 hour chill period (Site 3), as evidenced by R^2 values of -0.05126, 0.37812, and 0.13427,

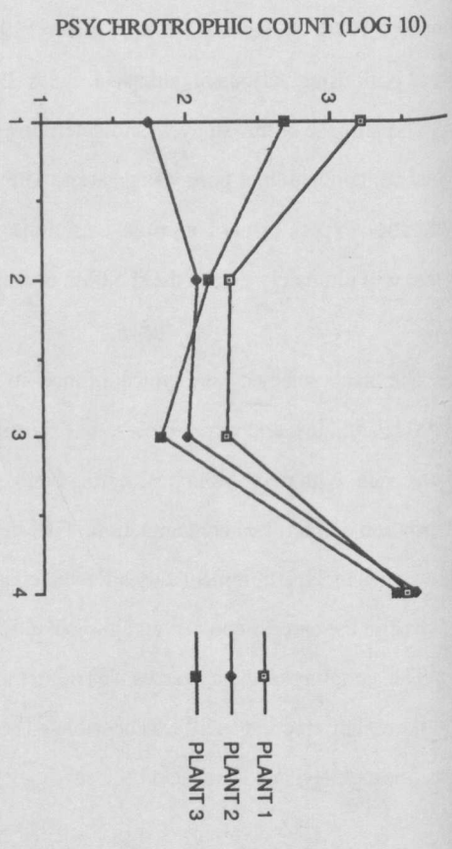

Figure 1. Contamination levels of psychrotrophic[1] spoilage bacteria on pork loins at four sampling sites[2] and 3 different plants, during slaughter and fabrication of pork carcasses

[1]Incubated at 5°C.
[2]Sampling sites: 1-after singeing and polishing; 2-after final rinse on slaughter floor; 3-after 18-24 hour chill, before cutting; 4-after cutting and fabrication prior to packaging.

Table 1. Contamination levels of five types of bacteria on pork loins at four sampling sites[1] during slaughter and fabrication of pork carcasses

Sampling Site	Psychrotrophs	Coliforms	Anaerobes	Aerobes	Lactics
1	2.549Y	1.3438Y	4.460X	4.942X	1.1014X
2	2.181Z	1.2776Y	3.580YZ	3.899Y	1.1454X
3	2.032Z	1.2615Y	3.326Z	3.441Z	1.0996X
4	3.508X	2.0988X	3.650Y	4.059Y	1.2154X
Std. Error	0.1026	0.0635	0.0987	0.0810	0.0486

[1]Sampling sites: 1-after singeing and polishing; 2-after final rinse on slaughter floor; 3-after 18-24 hour chill, before cutting; 4-after cutting and fabrication prior to packaging.
X,Y,ZMeans with the same superscript in the same column are not significantly different (P>0.05).

respectively. This would indicate that some factor other than slaughter floor contamination was influencing the level of contamination as the loins were being packaged, such as cross-contamination by the hands of the personnel doing the cutting and fabrication processes (Pether and Gilbert, 1971) or inadequate cleaning and sanitizing of equipment and contact surfaces (Williams et al., 1983).

Coliform counts were highly significant different ($P<0.01$) for sites within plants and sites among plants. The greatest coliform contamination was found at the final sampling site, but there were no significant ($P>0.05$) differences between the first three sampling sites (Table 1). There was also no significant ($P>0.05$) correlation between any of the sampling sites. The R^2 values for the sampling site after fabrication, compared to the sampling sites after singeing and polishing, after final rinse on the slaughter floor, and after an 18 hour chill, were 0.42477, 0.58632, and 0.59223, respectively.

The anaerobic bacteria counts on the loins were significantly ($P<0.01$) different for sites within plants and significant ($P<0.05$) for sites among plants (Table 1). The point in the total process where the greatest anaerobic contamination was found was at the sampling site immediately after singing and polishing of pork carcasses on the slaughter floor (Site 1). There was a highly significant ($P<0.0021$) correlation between anaerobic counts after fabrication and after singeing and polishing on the slaughter floor. The R^2 values for the sampling site after fabrication compared to the sampling sites after the final rinse on the slaughter floor, and after 18 hour chilling, were 0.33869, and -0.01560, respectively.

Significantly ($P<0.01$) higher counts for mesophilic aerobic bacteria were also observed at the sampling site immediately after singeing and polishing of pork carcasses on the slaughter floor (Table 1). Total microbial numbers decreased for both the anaerobes and aerobes as the carcass passed through the final rinsing step at the end of the slaughter process (Site 2). The R^2 values for the aerobic mesophiles was low indicating no correlation between sites for carcass contamination. The R^2 values for the sampling site after fabrication compared to after polishing, after final rinse, and chilling were 0.03028, 0.23027, and 0.25184 respectively.

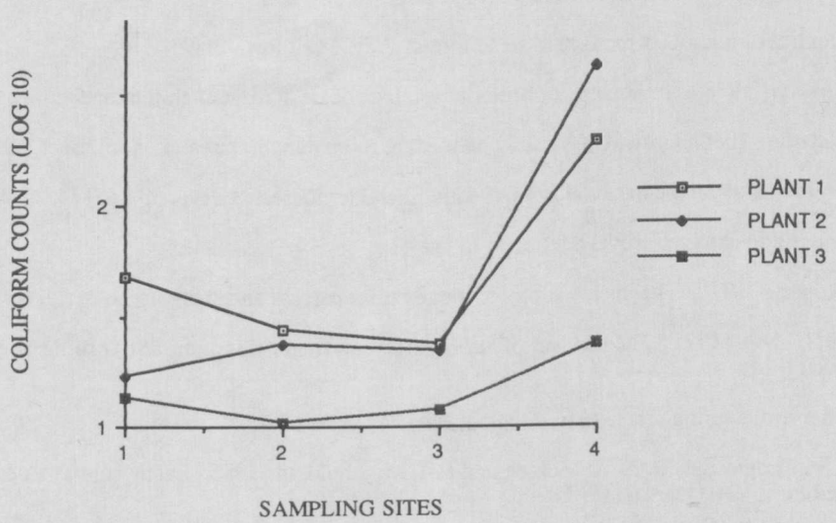

Figure 2. Contamination levels of coliform[1] bacteria on pork loins at four sampling sites[2] during slaughter and fabrication of pork carcasses

[1]Incubated at 35°C.

[2]Sampling sites: A-after singeing and polishing; B-after final rinse on slaughter floor; C-after 18-24 hour chill, before cutting; D-after cutting and fabrication prior to packaging.

There were no significant differences ($P>0.05$) in the contamination by lactic acid bacteria at any of the sites within plants (Table 1). This indicates that there were no changes in the counts as the carcasses moved through slaughter and fabrication. The results of all three plants were statistically equal. The R^2 values for the lactics were similar to the other types of bacteria tested. The R^2 values comparing the sampling sites after fabrication to after polishing was -0.26450, after fabrication to after final rinse was -0.04132, and after fabrication to after chilling was -0.14153, indicating no correlations were evident between the sampling sites.

The above results confirm the findings of Gill and Newton (1980) who found that mesophilic organisms dominated the spoilage flora of meat at 30°C, while psychrotrophic organisms were more predominant at temperatures of 20°C or lower. Biemuller et al. (1973) reported that improved showering techniques could reduce the total amount of bacteria on the carcass as it entered the coolers. The cold temperature of the coolers could also help to reduce the amount of contamination caused by mesophilic aerobic organisms, as the microflora shifted to a more psychrotrophic nature (Gill, 1986).

CONCLUSIONS

The area after fabrication and cutting of the boneless loins was the sampling site that provided the greatest source of microbial contamination of coliforms and psychrotrophic bacteria. The area immediately after singeing and polishing was the sampling site that provided the greatest source of mesophilic aerobic and anaerobic bacteria. The carcasses in the coolers had the lowest levels of contamination for all the bacteria. No strong correlation was found between contamination on the slaughter floor compared to that at fabrication, therefore, microbial counts on carcasses were affected by factors other than contamination from the scalding tank or during evisceration. Further study is needed to determine more specifically where, during fabrication, contamination of pork carcasses occurs.

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