Beef Carcass Microbial Contamination – Post Slaughter Numbers of Bacteria, Sources of Contamination and Variability of Data

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Forward

This publication is based upon a compilation of data obtained from Excel Corporation, covering the period of time from January 1, 1993 to December 31, 1995. The facts and tables contained within this publication, are designed to present microbiological data as it relates to beef carcass microbial contamination. Other information, which is based upon factual accounts, is presented to inform the reader on sources and variability of beef carcass contamination,

Summary

In differing geographical areas of the United States, four beef slaughter and fabrication facilities were chosen for this comparison. Each of the facilities provided carcass microbial data ranging from January 1, 1993 to December 31, 1995. This data was obtained from steer and heifer carcasses and represents approximately 50,000 individual sample collections. Carcasses were sampled at defined sites, over varying time frames, on the neck, midline (brisket), foreshank (outer), round, flank and hock. Samples were plated for Total Viable Count at 25°C.

Data from each plant were able to be analyzed together, as well as separately, as sampling methodology was consistent from plant to plant.

Variability between the microbial levels on carcasses from different facilities is shown and may be due to a variety of sources. Many of these sources, which are discussed, are associated with contamination that occurs between the time the carcass leaves the slaughter floor to the time it is chilled and ready for fabrication, (<48 hours).

Despite the variabilities, the data indicates that the areas best suited for microbiological zones of sampling, which give the best indication of overall microbial contamination levels, would be the foreshank, brisket and neck regions of the carcass.

Introduction

Over the last few years, the concern over the safety of meat has risen to alarming levels, and although the most sought after quality in a meat product, by all levels of the production chain, is freedom from pathogenic bacteria, the fact remains that it is simply not possible to achieve zero tolerance with today's current system. Institution of "risk management" programs, such as HACCP (Hazard Analysis Critical Control Point) and GMP's (Good Manufacturing Practices), will help to reduce these levels of pathogens and the risks associated as well as lowering the total viable bacterial count of the finished product.

Carcass microbial levels and they're relationship to the safety and shelf life of finished products has long been of interest to those in meat industry and academics. These levels, which can be extremely variable, will be based upon hygienic slaughter and the strict adherence to GMP's. Any change in process or practice will inevitably result in a variation of bacterial levels on carcasses but may or may not cause variation in safety or shelf life of the finished product. Although monitoring carcass contamination levels can be of benefit in determining whether or not adherence to HACCP and GMP's is occurring, it must be stated that microbiological determinations of a meat product, whether it be raw materials or finished product will not fully encompass the true microbiological quality of the entire carcass. In principal, large numbers of bacteria, some which cause spoilage and others illness, can be transferred to the carcass through fecal material, paunch contents and the hide. (15) In reality, the carcass can become contaminated by these sources and more (10). Eight environmental sources of bacteria to meat have also been described. (1).

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TABLE 1. Mean Levels of Viable Bacteria (APC @ 25°C) on Various Beef Carcass Surface Samples.

	MEAN cfu/cm²	
AREA SAMPLED	Geometric Mean	Log Mean
Foreshank	2,300	3.36
Round	550	2.74
Brisket	1,000	3.00
Neck	1,000	3.00
Hock	200	2.30
Flank	200	2.30
TOTAL	875	2.78

TABLE 2. Variation in Levels of Viable Bacteria (APC @ 25°C) on Various Beef Carcass Surface Samples.

	VARIATION cfu/cm²	
AREA SAMPLED	Standard Deviation	Log
Foreshank	21,700	4.34
Round	4,000	3.60
Brisket	1,600	3.20
Neck	3,100	3.49
Hock	200	2.30
Flank	430	2.63
TOTAL	5,171	3.26

Monitoring of carcass microbiological contamination, as it relates to various sources, both during slaughter and during processing, have been shown in various studies. (12)(15). The conclusions drawn from these studies are primarily based upon small scale, short term experimentation, which utilize only minimal data points. Since the majority of the work has been done during the actual handling and processing of the carcass (12)(15)(16), it is the purpose of this paper to focus on the issues of bacterial contamination that effect the carcass post slaughter and during the chilling process. The information will show what levels can be expected from large scale slaughter and fabrication facilities, over time. The paper will also present a discussion of the external sources that inevitably effect the overall microbial quality of a carcass.

Collection of Carcass Samples

In all facilities, samples were collected by trained laboratory technicians using standardized methodology. All samples were taken from carcasses that were less than forty-eight (48) hours post slaughter. Carcass samples from each facility, were obtained, on a daily basis from the round and foreshank regions of the carcass and represent both first and second shifts. Samples from the neck, brisket and hock regions were obtained on an as needed basis from specific facilities. (Figure 1) Each of the samples which represented four square inches (4 inch²), was sampled with a sterile cotton swab moistened in a peptone-tween solution. The swab was then placed in a single tube of sterile peptone or distilled water and transported immediately to the lab for dilution and plating. In all cases, samples were plated within two (2) hours of sampling.

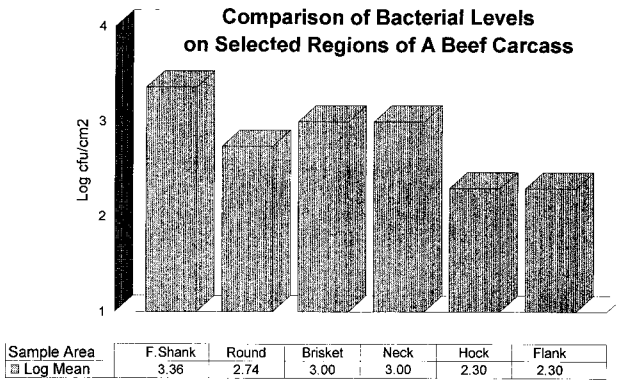
Analytical Methods

Modified AOAC methods and APC 3M Petrifilm were chosen for analysis of total viable count. Decimal dilutions from the sterile diluent were made if applicable, and plated to estimate numbers of viable bacteria on Standard Plate Count Agar (Difco) (BBL) or 3M Petrifilm (APC) and incubated at 25° C. Each participating laboratory followed QA/QC procedures with documented controls, thereby eliminating possible differences due to sepsis or inadequate technique.

Results

The results are presented in tables and graphs found in this report. All results are computed into colony forming units per square centimeter. Table 1 and Graph 1 present the mean levels of the viable bacteria recovered from specific zones or regions of the carcass in all facilities that participated. Tables 2a-2b and Graph 2 present the total standard devia-

GRAPH 1.



GRAPH 2.

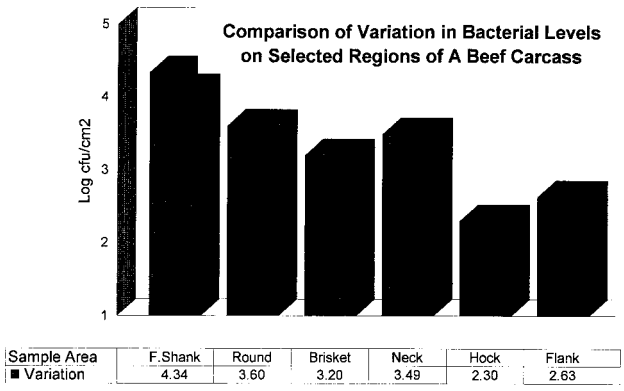


TABLE 3a. Comparison of Viable Bacterial Levels (APC @ 25°C) on Beef Carcass Surface Samples (Round Area) from Different Geographical Regions.

PLANT LOCATION	MEANcfu/cm² Geometric Mean	Log Mean
Northwestern	530	2.72
Northern	915	2.96
Central	170	2.23
Southern	155	2.19
TOTAL	443	2.53

TABLE 3b. Comparison of Viable Bacterial Levels (APC @ 25°C) on Beef Carcass Surface Samples (Shank Area) from Different Geographical Regions.

PLANT LOCATION	MEANcfu/cm² Geometric Mean	Log Mean
Northwestern	928	2.97
Northern	7,595	3.88
Central	341	2.53
Southern	108	2.19
TOTAL	2,243	2.89

tion of those viable bacteria. Tables 3a-3b/4a-4b and Graphs 3-4 present mean and standard deviation of the round and foreshank regions of the carcass in each individual facility, with each facility being shown as a specific geographical designation. Tables 5a-5b and Graph 5 show the log frequency of bacterial distribution on the foreshank in all facilities as it relates to summer and winter seasons. The Tables will show the mean and standard deviation expressed in both log and geometric notation. Graphs will be expressed in log notation only. Following is a brief summary of the results.

Viable aerobic bacteria (Aerobic Plate Count at 25°C) were found to be present from the surface of 100% of the carcasses tested in each facility, regardless of the region. (Table 1 and Graph 1).

When combining all samples from all areas, the geometric mean per square centimeter for the Aerobic Plate Count at 25°C was 875 cfu/cm². (Table 1) For individual regions, the geometric mean shown, indicates that the areas of highest contamination are the foreshank, brisket and neck regions of the carcass. (Table 1 and Graph 1). Variation in counts on the same areas also indicate that the greatest variation occurs in the neck, foreshank and brisket areas. The round area shows more variation than expected. (Table 2 and Graph 2).

Comparisons between individual plants, as shown, indicate that in the northern and northwestern facilities the mean and variation is generally higher than in the central and southern facilities. (Tables 3a-3b and 4a-4b and Graphs 3 - 4).

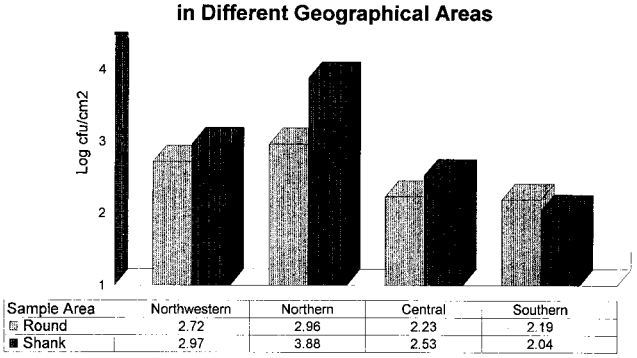
Comparison of seasonal variation is shown to affect the mean bacterial levels in the October through March (Winter Season) than in the April through September (Summer Season). Appreciable difference is seen in the standard deviation or variation of winter versus summer, and can possibly be attributed to cattle that are physically dirtier as a result of having been exposed to more precipitation and broader fluctuations in temperature (freezing and thawing). (Tables 5a-5b and Graph 5).

Discussion

There is no one method that will completely eliminate bacteria from steer and heifer carcasses during the slaughter, chilling or fabrication processes. The data represented in this publication, shows this, and agrees with historical data reported in 1993 by the U.S.D.A. Nationwide Beef Microbiological Baseline Data Collection Program with Aerobic Plate Count levels ranging normally around 100 to 10,000 colony forming units per square centimeter (17). It is lower, however, than the data reported by Ingram and Roberts in 1976. (5)

GRAPH 3.

Comparison of Viable Bacterial Levels on Beef Carcasses in Different Geographical Areas



GRAPH 4.

Variation in Viable Bacterial Levels on Beef Carcasses in Different Geographical Areas

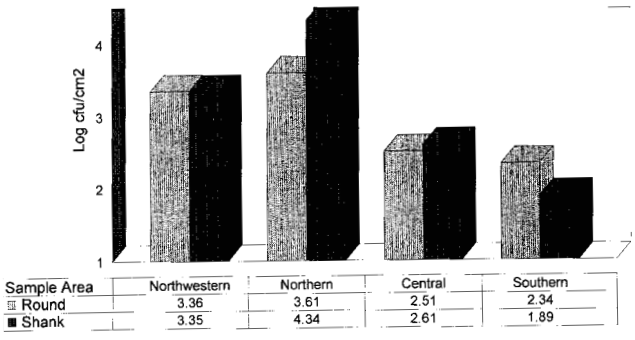


TABLE 4a. Variation in Levels of Viable Bacteria (APC @ 25°C) on Various Beef Carcass (Round Area) Surface Samples.

	VARIATION cfu/cm²	
PLANT LOCATION	Standard Deviation	Log
Northwestern	2,278	3.36
Northern	4,028	3.61
Central	325	2.51
Southern	217	2.34
TOTAL	1,712	2.96

TABLE 4b. Variation in Levels of Viable Bacteria (APC @ 25°C) on Various Beef Carcass (Shank Area) Surface Samples.

	VARIATION cfu/cm²	
PLANT LOCATION	Standard Deviation	Log
Northwestern	2,248	3.35
Northern	21,700	4.34
Central	403	2.61
Southern	77	1.89
TOTAL	6,107	3.04

Carcass APC levels can be affected by numerous sources and of those one or more may play a large part in contributing to the overall microbial quality. The following, as was mentioned, lists the sources that maybe shown to contribute to higher bacterial levels.

1. Carcass Wash

It has been demonstrated that when carcasses are washed, the effectiveness of washing will vary with time, volume, pressure and temperature, as well as the design of the cabinet used (10). Although the primary objective of carcass washing is the removal of bone dust, hair and blood, it has been shown to reduce viable bacteria on the surface of the carcass (2)(10) The action of the wash is designed to rinse the carcass from top down and as a result will have a tendency to redistribute the bacteria on the surface, resulting in higher levels at the lower end of the carcass (i.e. neck and foreshank). This may explain the levels seen in Table 1 -Graph 1.

It has also been shown that pressure and/or temperatures above manufacturers recommendations will not only hinder the removal of visible contamination but will also increase the viable count in specific areas. (2)

2. Temperature Controls

Temperature control is probably the most simple, important and effective control that can be exerted upon bacteria. From the time carcasses are slaughtered to the time that the finished product has been consumed, temperature plays a critical role.

Slaughter Floor

Railing out carcasses onto a retrim rail on the slaughter floor is often found to be common practice since the advent of zero tolerance. This practice is important in allowing time for proper removal of visible contamination, however, the possible attachment and multiplication of bacteria on the surface of the carcass will increase if given time. (6)(7) Since temperatures on the slaughter floor may well be at or exceed optimum growth temperatures for many bacteria, special procedures for handling dressed carcasses, which remain on the slaughter floor for longer than 30 minutes, should be considered.

Hot Boxes and Coolers

Adequate refrigeration is needed to handle the heat removal from chilling carcasses. If refrigeration is taxed or is inadequate, not only will the chill rate decrease, resulting in increased bacterial multiplication, (5) but contamination from condensation that may form can occur. It is important to understand the concepts and physics of refrigeration to properly design and construct coolers.

Carcass Spacing

The key to effective refrigeration is the circulation of air. If carcasses are not spaced when chilling to allow for proper air movement between them, increased levels of bacteria will occur. Where air movement is completely prevented from circulating around carcasses, or where they are

TABLE 5a. Seasonal Comparison in Levels of Viable Bacteria (APC @ 25°C) on the Shank Region of Beef Carcass Surface Samples.

	MEAN cfu/cm²	
SEASON	Geometric Mean	Log Mean
Winter Season (October through March)	2,300	3.61
Summer Season (April through September)	575	3.36

TABLE 5b. Seasonal Variation in Levels of Viable Bacteria (APC @ 25°C) on the Shank Region of Beef Carcass Surface Samples.

	MEAN cfu/cm²	
SEASON	Geometric Mean	Log Mean
Winter Season (October through March)	53,000	4.34
Summer Season (April through September)	2,270	3.35

GRAPH 5.

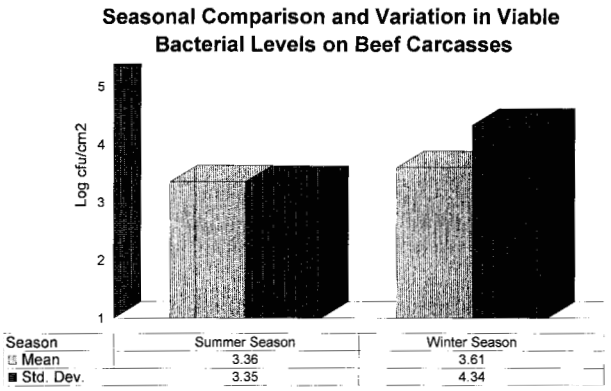
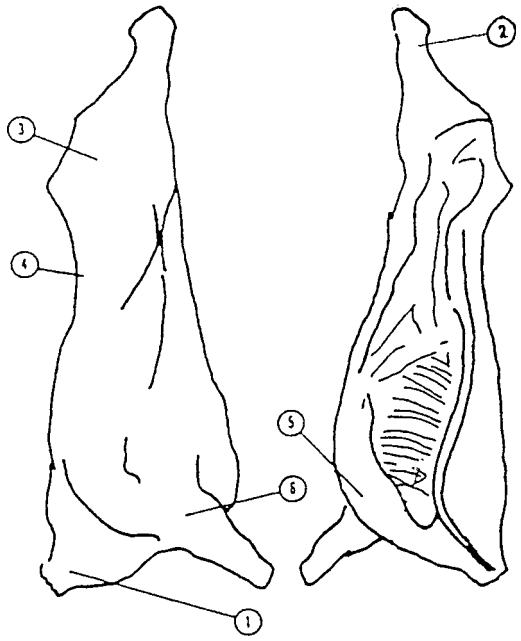


FIGURE 1.



Areas of sampling: 1. Neck; 2. Hock; 3. Round; 4. Flank; 5. Brisket; 6. Foreshank

touching, there can result the production of byproducts by bacteria, leading to souring or greening of the meat.(10)(13)

3. Spray Chilling

Spray chilling is often used, in combination with refrigeration, to accentuate the initial chilling of carcasses. It allows the surface to chill faster through the process of evaporation. Spray chilling can be quite effective when handled properly. Nozzles used to spray carcasses, as well as the water used can become contaminated and contribute to higher levels of bacteria on the carcass.(10)(6)

4. Sanitation

Although sanitation, as a daily process, is necessary to reduce bacterial levels on inanimate surfaces, it should be handled as any critical process in a facility would be. It is extremely important that the people performing the cleaning operation in the coolers, be properly trained in the job tasks that they are responsible for. When cleaning the hot boxes or coolers, minimization of steam is critical if carcasses are the immediate vicinity. Steam, as a water form, can carry bacteria from contaminated floors, drains and walls to the carcass surface and the refrigeration units (3) When daily cleaning requires removal of fat and debris from the floors of the coolers, it is of utmost importance that the water pressure be minimal, and the direction of the spray, be away from the carcasses that are chilling. Use of high pressure hoses can cause splattering from the floor to the necks and lower regions of the carcass. It has been shown that this can result in increased levels of bacteria including coliforms and generic E. coli.(4)

Conclusion

Consideration of all sources of contamination should be taken when evaluating post slaughter carcass microbial data. Although the primary focus of carcass contamination has been the relationship of microbial data to hygienic slaughter floor dressing procedures, this paper has provided some insight to other areas that may ultimately affect the final microbial quality of a chilled carcass. Variations in the data shown in this paper are most likely due to one or more of the listed effects. Considering the differences in animals and slaughter practices in each of the facilities, the bacterial levels detected and shown, do not suggest that carcasses produced are of either excellent or poor microbial quality, however, a sampling scheme of this sort could legitimately serve as a useful tool in monitoring process and production. Over time, it is probably safe to assume that a normal level of viable bacteria (APC) can be determined from specified regions of the carcass using control charting, to which upper control limits can be applied. If using the microbial data for determining proper adherence to dressing procedures it is probably best to use more than one site, particularly in the areas of pattern marking such as the midline (brisket), shank and round. If using the data to determine microbial quality of trimmings that will be further processed, the ideal locations would be those that represent the regions where trimmings will be sourced such as the neck and foreshank. In either case, consistent methodology, analytical procedure and analysis of data is important. Institution of any microbial specifications should always be based upon adequate and valid information over time to determine what can be achieved with good manufacturing practices.

References

1. Davey, K.R. and M.G. Smith. 1989. A laboratory evaluation of a novel hot water cabinet for the decontamination of sides of beef. Int. J. of Food Sci. and Tech. 24:305-316.
2. Excel Corp. 1992. Data from comparison of bacterial levels before and after carcass wash.

3. Excel Corp. 1994. Data from project determining steam as a medium for carrying bacteria.
4. Excel Corp. 1994. Data confirming relationship of coliform/E.coli numbers to neck trim in ground beef.
5. Excel Corp. 1995. Data from carcass surface chilling project.
6. Farber, J.M. and E.S. Idziak. 1984. Attachment of Psychrotrophic Meat Spoilage Bacteria to Muscle Surfaces. J. Food Protect. 47:92-95.
7. Gill, C.O. and K.G. Newton. 1982. Growth of Bacteria on meat at room temperature. J. Appl. Bacteriol. 49:315.
8. Gill C.O. 1976. Substrate limitation of bacterial growth at meat surfaces. J. Appl. Bacteriol. 41:401.
9. Gill, C.O. 1986. The Control of Microbial Spoilage in Fresh Meats. Advances in Meat Research. 2:49-87.
10. Grau, F.H. 1986. Microbial Ecology of Meat and Poultry. Advances in Meat Research. 1:1-47.
11. Hobbs, B.C. 1968. Food Poisoning and Food Hygiene. 2nd Ed. London: Edward Arnold.
12. Ingram, M. and T.A. Roberts. 1976. The Microbiology of the red meat carcass and the slaughterhouse. Roy. Soc. of Health J. 96:270-276.
13. Jay, James M. 1992. Modern Food Microbiology. 18:434-453.
14. Niven, C.F. Jr. 1986. Perspective on Potentially Fruitful Research Areas. Advances in Meat Research. 13:397-410.
15. Patterson, J.T. and P.A. Gibbs. 1978. Sources and properties of some organisms isolated in two abattoirs. Meat Sci. 2:263.
16. Roberts, T.A.,W.R. Hudson and O.P. Whelehan. 1984. Number and Distribution of Bacteria on Some Beef Carcasses at Selected Abattoirs in some Member States of the Europen Communities. Meat Sci. 191-205.
17. U.S.D.A./F.S.I.S. Microbiology Division. 1994. Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers. October 1992 - September 1993.