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Improving the Microbiological Quality of Meat

James S. Dickson and Gregory R. Siragusa

Introduction

Microbial contamination of animal carcasses is a result of the necessary procedures required to process live animals into retail meat. The contamination can be minimized by good manufacturing processes, but the total elimination of bacteria of public health significance is difficult, if not impossible. A variety of methods have been developed to improve the microbiological quality of meat, although most of the current methods focus on washing and sanitizing the carcasses, prior to chilling.

The beef slaughter process begins by humanely stunning the animal, bleeding, and then removing the hooves and head. The hide is removed, and the carcass is eviscerated and split into halves. The carcass halves are washed and then cooled to refrigeration temperatures. The initial research on carcass washing was with washing the split carcass, which, as the final step before chilling, was intended to remove as much of the total physical and microbiological contamination as possible. Manual washing was refined with equipment that automatically washed the carcasses. The automated systems were more consistent in operation than a manual system, and also reduced the amount of water used in washing. A further refinement of the automated systems was the inclusion of a sanitizing rinse immediately after washing. The sanitizing rinse uses food grade antibacterial compounds to inhibit the growth of any bacteria remaining after the initial wash. The sanitizers typically are organic acids, such as acetic (vinegar) or lactic acid (naturally occurring in cheese).

The automated washing and sanitizing systems were successful in improving the microbiological quality of beef carcasses. However, since much of the contamination of the surface of the carcass occurs during the hide removal, a second washing station was inserted immediately after hide removal and prior to evisceration (termed "pre-evisceration" washing). The process of pre-evisceration has been patented by a major U.S. meat packer.

The traditional method of cooling carcasses was by forced air refrigeration. In the 1970's, a new cooling process was developed which misted cold water on the carcasses in conjunction with refrigeration. This new process increased the cooling rate by evaporative cooling, and reduced the weight loss of the carcass which normally occurred during traditional chilling. The process used chlorinated water to inhibit bacterial growth, and was patented as "chlor-chil." Since that time, other sanitizers have been incorporated into the spray water on an experimental basis.

Although there were some data in the scientific literature on each of these processes individually, we wanted to evaluate the entire system under controlled conditions. Therefore, our objectives were to determine the effectiveness of pre-evisceration and post-evisceration washing and sanitizing, followed by spray chilling, in reducing the population of salmonellae on beef. This research was conducted in the laboratory, as a feasibility study to establish processing guidelines for full-scale equipment currently being installed in the abattoir at the MARC.

Procedure

Bacterium. A strain of Salmonella california, naturally resistant to a potent antibacterial compound (naladixic acid), was grown and maintained in tryptic soy broth, a general bacterial growth medium. The marker bacterium was suspended in manure collected from cattle fed a corn silage diet prior to use, to simulate a "worst case" contamination situation. The marker bacterium was easily differentiated from the other bacteria in the manure by its ability to grow on selective culture media containing naladixic acid.

Tissue. Post-rigor beef tissue was obtained as boneless trim from the abattoir at the MARC. The tissue was separated into lean and adipose tissues, sliced into 2 mm thick slices, sterilized with gamma radiation, and stored frozen until use. Prior to use, the slices were cut into squares, and tempered to room temperature. Tissue produced in this manner had previously been determined to be representative of prerigor tissue, in terms of numbers of bacteria which would attach and the sensitivity of the attached bacteria to organic acids.

Experimental design. The tissue samples were inoculated by immersing them in the manure containing the marker strain of salmonella for 5 min. After inoculation, the tissue was washed and sanitized (pre-evisceration), allowed to stand for 10 min to simulate the normal delay in processing, washed and sanitized a second time (post-evisceration), and then spray chilled. Washing and sanitizing treatments were simulated by vigorously washing the tissue in distilled water (washing) or 2% acetic acid (sanitizing). Because previous research had indicated an enhanced sanitizing effect if the acid was warmer than room temperature, the acid was applied at 131°F. Spray chilling was simulated by briefly dipping the tissue in 41°F water at 30 min intervals for 4 hours.

Enumeration of bacteria. The samples were homogenized and bacterial populations were enumerated on a variety of culture media. These media included a nonselective, general growth medium (TSA) and two media which were specifically intended to isolate salmonella (EF-18 and MAC). Naladixic acid was added to all three media to specifically select for the marker bacterium. Use of both the nonselective and selective media allowed the potential differentiation between normal, healthy bacterial cells and those which may have been injured by the sanitizing process.

Results

A single washing treatment, comparable to a final post-evisceration wash, removed approximately 90-95% of the contaminating bacteria from lean and adipose tissue, when used in combination with spray chilling. The inoculation process left the tissue samples covered with manure, and the reduction in bacterial numbers was due primarily to the removal of gross physical contamination. This emphasizes the importance of carcass washing, since much of the initial bacterial population can be removed by adequate washing. The combination of pre- and post-evisceration washing and sanitizing reduced the population by another 90% on lean tissue and by greater than 99% on adipose tissue. If the ini-
Initial population of salmonellae were 1000 cells per square inch, these processes in combination would reduce the population to approximately ten cells per square inch on lean and one cell per square inch on adipose tissue. These processes would be expected to result in comparable reductions in the populations of other bacteria, including both spoilage and bacteria of public health significance.

Bacteria on adipose tissue tend to be more susceptible to organic acid sanitizers than those on lean tissue, as this report and other research have demonstrated. This effect has been attributed to the difference in the microenvironments on the surface of these two tissue. Bacteria apparently attach equally well to either lean or adipose tissue and, once attached, are equally difficult to remove. There is some evidence, based on electron micrographs, that bacterial cells may collect in crevices in the lean tissue. This might provide some physical protection from sanitizing agents, in that water trapped in the crevices may not allow direct contact between the sanitizer and bacterial cell. Alternately, water soluble components in the lean tissue may act to buffer the acid and chemically protect the bacteria. The practical implications of this are that much of the carcass surface is covered with adipose tissue, so the greater reductions on adipose tissue may be more like the reductions on actual carcasses.

Construction of the pre-evisceration washer in the abattoir at MARC is expected to be completed in the near future. The post-evisceration washer is operational, and the spray chiller is functional, although some additional refinements are required. With the completion of these systems, research under actual processing conditions will be performed to confirm the laboratory findings.