Session 6.3 Meat technology and processing Cooked products Fermented products

L 1 MEAT TECHNOLOGY AND PROCESSING - CURRRENT ISSUES AND TRENDS

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Introduction

Major issues face the meat industry in the United States (U.S.), and it is assumed that these issues are similar throughout the international meat industry. Though not comprehensive relative to all the issues facing the U.S. industry, the following discussion will hopefully set the stage for your evaluation and discussion of selected technologies and processing protocols and related issues that impact their use. Recent research at Kansas State University serves as the basis for the subsequent presentation.

U.S. consumers have voiced their opinions about a number of issues including meat quality, meat safety, and convenience. Overwhelmingly, U.S. consumers want a consistently palatable product, that is safe, convenient, and of course affordable. In order to achieve the quality goals several technologies have proven historically effective. However, those technologies pose potential safety issues as defined by the United States Department of Agriculture (USDA). For example, the technologies (i.e., mechanical tenderization) that have been relied upon for years create a class of "non-intact" products. That class of product has prompted USDA to solicit scientific information to adequately assess the risks associated with non-intact products. In response to the need for scientific information, pathogen inoculation procedures have been developed for pathogen application to product prior to treatment with, for example, mechanical tenderization, restructuring, and/or injecting. Subsequently, the thermal/cooking treatment(s) required to eliminate pathogen concerns are determined. In addition to the thermal treatments, other intervention strategies are proposed as complimentary control measures.

From a historical standpoint, two incidences have been the basis for a significant paradigm shift in the U.S. regulatory atmosphere. In 1993, an *E. coli* O157:H7 outbreak in ground beef in the northwest U.S. as well as a fermented sausage related outbreak in 1994 on the west U.S. coast set the stage for a number of concerns that impact U.S. meat industry. Consequently USDA is now questioning or will question the safety of all non-intact products whether consumed domestically, exported, or imported.

Blade Tenderization

The National Advisory Committee on Microbiological Criteria for Foods (NACMCF), Meat and Poultry Subcommittee (1977) stated that "*Due to the low probability of pathogenic organisms being present in or migrating from the external surface to the interior of beef muscle, cuts of intact muscle (steaks) should be safe if the external surfaces are exposed to temperatures sufficient to effect a cooked color change.*" However, if the surface of an intact muscle or muscle system is violated by mechanical tenderization or similar processes, contamination may be carried from the surface to the interior of the cut. The NACMCF, Meat and Poultry Subcommittee (1997) stated that there is a lack of scientific data to address the hazards associated with those processes that may cause translocation of pathogens.

Beef

Assuring tenderness of meat cuts has been a significant focal point of industry for many years. Blade tenderization of large subprimal cuts offers a cost effective and efficient means of achieving uniform tenderness in retail and food-service cuts. While sensory aspects of blade tenderized meats have been extensively researched, microbiological quality and associated health risks have not been thoroughly researched as per USDA requirements and demonstrated to USDA. Ground beef is generally cooked to medium to well done in the U.S. as restaurants and consumers now recognize that *E. coli* O157:H7 and other pathogens may be present throughout the product. However, consumers generally perceive steaks as being intact muscle (even when blade tenderization has occurred) and often cook to lesser degrees of doneness. Mechanically tenderized steaks may harbor pathogenic bacteria internally, thereby increasing the risk of foodborne infection if not thoroughly cooked. The objectives of the following research was to determine the extent of microbial translocation from the surface to the interior of subprimal due to blade tenderization, and to determine adequate cooking protocols to eliminate *E. coli* O157:H7 from the interior of blade tenderized steaks.

Beef top sirloin subprimals were inoculated with 10^6 or 10^3 CFU/cm^2 and passed once through a Ross blade tenderization unit. Core samples were analyzed, revealing a translocation of 3-4 percent of the surface inoculum to the geometric center of the subprimal. Thermal destruction of *E. coli* O157:H7 in blade tenderized (BT) steaks compared to non-tenderized (NT) steaks of three thicknesses using an oven broiling cooking method was evaluated. Subprimal surfaces were inoculated to a level of 10^7 CFU/cm^2 and blade tenderized. Steaks cut from these subprimals were cooked to internal temperatures from 48.9 to 76.7°C (120 to 170°F) and subsequently analyzed for surviving *E. coli* O157:H7 populations. Results showed similar reductions ($P>0.05$) in BT and NT steaks except at the lowest cooking temperature where BT steaks showed lower reductions. At internal steak temperatures of 60°C (140°F) and higher, *E. coli* O157:H7 population reductions were >6 log cycles in both steak types

at all steak thicknesses using the oven broiling method. At 54.4°C (130°F), ca. 5 log cycle reductions were noted for both steak types. With oven broiling to moderate internal temperatures, blade tenderized steaks do not seem to pose any greater risk of *E. coli* O157:H7 than non-tenderized steaks. (Phebus et al., 1999)

The cooking requirement may be less stringent if processors can assure the microbiological quality of raw materials. HACCP plans incorporating intervention strategies designed to provide that assurance are being investigated.

Pork

The potential of translocation of *Salmonella* spp. from the surface to the interior of whole muscle pork via the blade tenderization process was also evaluated. Pork loins were inoculated with 10^5 or 10^3 CFU/cm^2 (high and low inoculum levels) and passed once through a Ross blade tenderization unit. Core samples were analyzed, revealing a translocation of 1 percent and 7 percent at higher and lower inoculum levels, respectively. The thermal destruction of *Salmonella* spp. in blade tenderized pork loin chops of two thicknesses (1.27and 2.54 cm) using a commercial grill was evaluated. Pork loin surfaces were inoculated to a level of ca. 10^5 CFU/cm^2 and blade tenderized. Chops cut from the pork loin were cooked to internal temperatures from 60 to 82.2°C (140 to 180°F) and subsequently analyzed for surviving *Salmonella* populations.

Cooking blade tenderized chops resulted in an increase of reductions from 2.98 to 4.58 log CFU/g at the respective temperatures of 60 to 82.2°C (140-180°F). Proper internal cooking temperatures are key to assuring the safety of these non-intact products particularly with *Salmonella* spp. as the target organism. (Lambert et al., 2000)

Adoption of a HACCP or equivalent system in all slaughter operations, incorporating antimicrobial intervention systems such as carcass washes or other thermal treatments, should further reduce surface contamination prior to mechanical tenderization. USDA reported lower incidence rates for *Salmonella* spp. after implementation of the Pathogen Reduction/HACCP final rule in the meat slaughter and processing operations. Thus a lower target internal temperature may be adequate to destroy the possible contamination levels on the pork loin surfaces.

Restructuring

Meat restructuring using, for example, binding technologies like fibrinogen and thrombin or transglutaminase, or extracted myosin provide quality, economical, nutritional, and marketing advantages in meat processing. As previously mentioned, food poisoning outbreaks with *Escherichia coli* O157:H7 have frequently been attributed to ground beef consumed after cooking that was insufficient to destroy pathogens that were translocated from the surface to the meat interior. Restructured steaks may be perceived as more like intact muscle steaks than as ground beef. Because of this perception, restructured steaks may be cooked at temperatures inadequate to destroy surface microbial contamination that may have been carried to the interior of the restructured product. The objectives of the research were to determine the extent of *E. coli* O157:H7 translocation in restructured beef and to determine adequate cooking protocols to eliminate *E. coli* O157:H7 from their interior as required by USDA.

Distribution of *Escherichia coli* O157:H7 in Fibrimex® restructured beef from artificially inoculated meat pieces and destruction of *E. coli* O157:H7 in restructured beef steaks prepared from artificially inoculated meat was evaluated following oven broiling and grilling. *Longissimus dorsi* trimmings were inoculated with fluorescently marked *E. coli* O157:H7 cells to microscopically identify bacterial distribution throughout restructured steak cross-sections. *E. coli* O157:H7 fluorescent density was observed along the binding surfaces where meat pieces were attached. Research quantified the level of *E. coli* O157:H7 throughout the entire thickness of restructured beef. Cross-sectional slices of core samples from the steaks showed that bacterial contamination was evenly distributed (ca. 10^6 CFU/g). The extent of *E. coli* O157:H7 reduction achieved during cooking was determined. Beef trimmings were inoculated to a level of 10^7 CFU/g and used to prepare restructured beef chubs. Restructured steaks of three thicknesses (1.27, 2.54, and 3.81 cm) were sliced from the chubs and cooked to one of six target internal temperatures ranging from 48.9 to 76.6°C (120 to 170°F) by commercial gas grill or oven broiler. Broiling was more effective than grilling, although *E. coli* O157:H7 survival decreased as endpoint temperatures increased incrementally. Reductions over the cooking internal temperatures ranged from ca. 1.0 to 4.5 log CFU/g. To achieve an adequate level of safety confidence according to USDA standards, restructured steaks should be cooked in a manner similar to ground beef; to an internal temperature of at least 71.1°C (160°F). (Ortega-Valenzuela et al., 2001)

Again, cooking requirements may be lessened if processors can assure the microbiological quality of raw materials. HACCP or equivalent plans incorporating intervention strategies designed to provide that assurance are being investigated.

Marination/Injection

Needle injection for tenderization of pork was evaluated due to the possibility of translocating surface bacteria to the interior of the meat. The previous studies showed that blade tenderization or other processes may translocate surface bacteria to the interior of the meat where they may survive inadequate cooking.

Cooking temperatures and risks associated with *Salmonella* spp. and needle injected pork loins and needle injected pork loins with a spice rub were evaluated. Also the depth of penetration that the bacteria moves during these processes was also evaluated.

Pork loins were inoculated with ca. 10^5 and 10^3 CFU/cm^2 and passed once through a needle injection unit (Fomaco-Reiser, Copenhagen, Denmark). *Salmonella* spp. was translocated (4 and 8% at higher and lower inoculum levels, respectively)

to the interior of the muscle. The thermal destruction of *Salmonella* spp. in pork chops obtained from needle injected pork loins and needle injected pork loins marinated with a spice rub was determined. Chops of two thicknesses (1.27and 2.54 cm) were evaluated for destruction of *Salmonella* spp. by cooking on a commercial grill. Pork loin surfaces were inoculated to a level of 10^6 CFU/cm^2 and needle injected. Chops cut from the pork loin were cooked to internal temperatures from 60 to 82.2°C (140 to 180°F) and subsequently analyzed for surviving *Salmonella* spp. populations. Cooking of needle injected pork loin chops to target internal temperatures of 60 to 82.2°C showed reductions of 1.71 to 4.73, respectively from initial levels of 6.16 log CFU/g. Cooking of rub marinated chops to the same target end internal temperatures resulted in reductions of 1.60 to 3.53 log CFU/g of *Salmonella* spp. from an initial level of 5.27 log CFU/g. (Lambert et al., 2000)

Fermented Sausage Production

USDA has also required that fermented sausage technologies be evaluated and Lebanon bologna was selected as a test case based upon the Lebanon bologna industry's request.

A fermented sausage process that achieves a five-log reduction of *E. coli* O157:H7 meets USDA requirements. Research was conducted to define a five-log reduction process. Lebanon bologna batter containing starter culture (*Pediococcus*, *Lactobacillus*, and *Micrococcus* spp.) was inoculated with *E. coli* O157:H7. The fermentation process consisted of 8 hrs at an internal temperature (I.T.) of 27°C (80°F) (Stage 1), then 24 hrs at 38°C (100°F) I.T. (Stage 2), followed by 24 hrs at 43°C (110°F) I.T. (Stage 3), and a final heat process of 46°C (115°F) I.T. for 5 hrs (Stage 4). The log CFU/g counts ranged from 7.50-7.78, 6.96-7.07, and 4.84-5.07, respectively, for raw batter and samples taken at the end of Stages 1 and 2. Log CFU/g counts were different ($P<0.05$) for samples taken at the end of Stage 2 than for the raw batter and samples taken at the end of Stage 1. A greater than five-log reduction was achieved after 6 hours of Stage 3.

All enrichment samples were negative during Stage 4 at 2 and 5 hrs. The average pH and moisture:protein ratio ranged from 4.4-4.6 and 3.7-3.8, respectively. Therefore, a five-log CFU/g *E. coli* O157:H7 recovery reduction process was defined. (Karr Getty et al., 1999)

Cook-in-the-Bag

The use of cook-in vacuum packaging processing technology has been increasing since its beginnings in the early 1970's. The French coined the process name sous vide which means under vacuum. Georges Pralus, a chef in France, is credited with developing the process in the mid 70's. A patent in 1971 by C. A. Ready, assigned to W. R. Grace and Company contained the basic concepts of vacuum packaging raw food materials in laminated plastic packaging materials, cooking, chilling and subsequent storage of these products (Ghazala, 1998). In the U.S., use of cook-in bag technology has increased dramatically due to the demand for Home Meat Replacement (HMR) products, which is expected to reach U.S. $67 billion is sales by 2001 (Tomei and Cassono, 1999). In Europe and Japan, large sections of supermarkets are devoted to chilled entree's. France experienced 100% growth of chilled entree sales between 1983 and 1987 (Beauchemin, 1990).

Though not being in the classical "non-intact" product category the safety challenges are similar for cook-in-the-bag products. Major concerns with cooking under vacuum are the growth of pathogenic anaerobic, psychrotrophic, heat resistant spore and toxin forming bacteria as a result of temperature abuse (Beauchemin, 1990). Ghazala (1998) reported the bacteria of concern are *Listeria monocytogenes*, *Clostridium botulinum*, *Clostridium perfringens* and *Bacillus cereus*.

To produce safe cook-in-the-bag products, it is recommended by USDA that heat treatment equivalent to 90°C (194°F) for 10 min be applied followed by rapid chilling (Ghazala, 1998). That heat treatment is normally greater than for sous vide products. USDA considers chilling from 55°C (130°F) to 26.6°C (80°F) in 1.5 hours or less and from 26.6°C (80°F) to 4.4°C (40°F) in 5 hours or less as a validated process schedule to control growth of *C. perfringens* and *C. botulinum*. This is considered to be a "safe harbor" approach by USDA. Any other cooking/chilling protocol has to be validated against the pathogens of concern. Research is being focused on identifying and validating a variety of "equivalent" protocols.

Ready-To-Eat Products

Ready-to-eat products (RTE) are processed to ensure that pathogens are eliminated and many of those products would be considered non-intact. However, upon packaging or other post-process handling for final sale the surface may become contaminated with pathogens such as *Listeria monocytogenes*.

Recent *Listeria monocytogenes* outbreaks implicating RTE meat products have increased concern in the U.S. regulatory agencies and RTE meat industry. The U.S. industry has not been successful in achieving a level of sanitation and biosecurity that would render these products free of *L. monocytogenes*.

Two possible avenues to ensure that RTE meats are free of *L. monocytogenes* are to (i) aseptically process and package RTE meat products under strict sanitation, and (ii) surface pasteurize the unsliced meat and meat products (in-package) to eliminate the pathogen. Saturated steam based pasteurization method has been effectively used in the beef slaughter industry to decontaminate the carcasses. Post-process pasteurization of RTE meats holds promise as this would ensure that the products; even if contaminated after processing would be safe.

The objective of the following study was to evaluate and validate a saturated steam-based system (Stork-RMS-Protecon) for in-package pasteurization of RTE meat products for control of *Listeria monocytogenes*.

Hard salami, turkey breast, roast beef, and cured hams were surface inoculated with *L. monocytogenes*, vacuum packaged and steam pasteurized at 96.1°C (205°F) for either 0, 2, 3, or 4 min. Steam pasteurization of hard salami at 96.1°C (205°F)

pasteurization temperature resulted in 4.15 and 4.26 log CFU/sq. cm reductions of *L. monocytogenes* at 2 and 4 min. residence times. Pasteurization of cured hams at 96.1°C (205°F) resulted in 2.94, 3.73 and 4.52 log CFU/sq. cm reduction in *L. monocytogenes* at 2, 3, and 4 min. residence times, respectively. Similar processing conditions resulted in 2.67, 3.57, and 4.48 log CFU/sq. cm reductions of *L. monocytogenes* for roast beef and 1.99, 2.4, and 1.83 log CFU/sq. cm reductions for turkey breast. It was concluded that saturated steam based post-process pasteurization system was effective in controlling *L. monocytogenes* surface contamination in RTE meat products. (Gill et al., 2000)

Future Considerations

Discussions relative to meeting USDA standards for risk assessment of various technologies including those discussed above have centered around establishing "real world" contamination levels. For example, the highest level of pathogen that has been encountered and other intervention measures required to eliminate the pathogen risk are being considered. Additionally, it is proposed that HACCP and good manufacturing practice plans or other equivalent systems that minimize or eliminate pathogens in raw materials all along the processing continuum be used. Both approaches could minimize the cooking/heat required by USDA to eliminate pathogen risks of the various technologies. USDA is still considering the non-intact issue and ruling(s) will be forthcoming. It is also noted from this research that not all non-intact products pose the same risk. Therefore, technology specific rulings appear in order. The research reported in this manuscript provides a significant part of the body of research being considered by USDA.

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