52 Defining spoilage: What is shelf life and how is it determined? T. L. Brown[1], S. L. Jaax[1], M. M. Brashears[2], and S. J. Eilert*[1], [1]*Cargill Meat Solutions*, *Wichita, KS*, [2]*Texas Tech University*, *Lubbock*.

The objective of this review paper is to discuss the definitions and methods used to determine the shelf life of meat products. Predicting shelf life accurately impacts multiple facets of the food industry, including production, consumers and regulatory compliance. The economic impact of shelf life on consumer confidence and market position can be dramatic. The effort spent on modifications to formulation and packaging in attempt to maximize shelf life and product quality can be staggering. Shelf life is defined as the length of time that food and other perishable items are given before they are considered unacceptable for sale from a sensory, nutritional or safety perspective. Microbial growth or predictive microbiology is widely used to determine shelf life. To use microbial data requires making the assumption that a product has reached the end of its shelf life when the microbial count reaches a predetermined level. This assumption is usually made based on historical knowledge of the product. Even with an abundance of historical product knowledge, statements regarding shelf life based on microbial data may not hold true. Microbial growth rates are affected by product type, formulation, packaging, storage conditions, beginning microbial load, and many other variables. Some products will be considered spoiled at a low microbial load due to physical characteristics like odor, color or gas production. However, other products containing an excessive microbial load will still be acceptable referring to the definition of shelf life. Traditional microbial counts or predictive microbiology does not determine if a product is spoiled. Shelf life or product acceptability is a measure of product quality not microbial counts. Microbial counts may give an indication about the product stability but will not determine shelf life. Chemical or physical measurement is a more accurate gauge of shelf life by observing nutritional degradation or sensory acceptability.

Key Words: Shelf Life, Spoilage, Meat

53 Is there a link between food safety and food spoilage? J. C. Brooks*, M. M. Brashears, and M. F. Miller, *Texas Tech University*, *Lubbock*.

Microbial food safety is a general term that refers to the presence of harmful or pathogenic bacteria in foods that could cause human illness if consumed. Spoilage is a subjective measurement of quality and includes chemical and/or physical changes in color, texture, odor, taste, and microbial counts. Some researchers believe controlling microbial growth is the most important factor in controlling the spoilage of meat and choose to measure spoilage by quantifying bacteria. This practice of measuring bacteria as an indicator of spoilage has resulted in a perceived relationship between spoilage bacteria counts and pathogenic bacteria counts. This perception has been supported by several research scientists who have documented their concern that certain packaging techniques, namely Modified Atmosphere Packaging, may inhibit the growth of microorganisms that are typical indicators of spoilage to consumers and promote the growth of food pathogens. To determine if a link exists between food safety and spoilage, studies were conducted to measure the spoilage (trained and consumer panels for color and odor; total aerobic plate counts, coliforms, and lactobacillus bacteria; and oxidative rancidity) and safety (Escherichia coli O157:H7 and Salmonella spp inoculated samples) characteristics of ground beef and poultry packaged under low-oxygen and high-oxygen modified atmospheres. Results indicate food pathogen levels are not related to food spoilage (microbial and sensory traits) in ground beef patties packaged under high-oxygen and low-oxygen (with 0.4% CO) modified atmospheres. Similar results were observed for chicken drums and breast meat packaged in low-oxygen environments containing 0.4% CO. The lack of data to support a relationship between food safety and food spoilage is likely the result of several factors affecting the chemical and physical changes that occur during the storage of meat products. Storage temperature, package atmosphere, light intensity, meat constituents, initial microorganism loads, indigenous enzyme activity and consumers collectively define food spoilage and appear to have little effect on the growth and survivability of food pathogens under controlled conditions.

Key Words: Spoilage, Safety, Packaging

Food Safety - Livestock and Poultry: Current and Future Salmonella Challenges

54 Gastrointestinal microbial ecology and the safety of our food supply as related to *Salmonella*. T. R. Callaway*, T. S. Edrington, J. A. Byrd, R. C. Anderson, R. B. Harvey, K. J. Genovese, J. L. McReynolds, and D. J. Nisbet, *Food and Feed Safety Research Unit*, *College Station, TX*.

Salmonella causes an estimated 1.3 million cases of human illnesses and more than 500 deaths annually in the U.S. This was estimated at an annual cost to the economy of approximately $2.9 billion. *Salmonella enterica* is comprised of more than 2,500 serotypes. With this genetic and environmental diversity serotypes are adapted to live in a wide variety of hosts using non-pathogenic and pathogenic lifestyles depending on environmental conditions. Thus *Salmonella* presents a multi-faceted threat to food production and safety. *Salmonella* have been isolated from all food animals and can cause morbidity as well as mortality in swine, cattle, sheep, and poultry. The link between human salmonellosis and host animals is most clear in poultry. During the early part of the 20th century a successful campaign was waged to eliminate fowl typhoid caused by *Salmonella* Gallinarum/Pullorum. Microbial ecology is much like macroecology; environmental niches are filled by adapted and specialized species. Elimination of *S.* Gallinarum cleared a niche in the on-farm and intestinal microbial ecology that was quickly exploited by *S.* Enteriditis and other serotypes that live in other hosts, such as rodents. In the years since, human salmonellosis cases linked to poultry have increased to the point that uncooked chicken and eggs are regarded as toxic in the zeitgeist. Salmonellosis caused by poultry products have increased significantly in the past 5 yr, leading to federal efforts that target reducing the incidence of *Salmonella* in chickens below the current 19% rate. Prevalence of *Salmonella* in swine and cattle is lower, but still poses a threat to food safety and production efficiency. Thus, approaches to reducing *Salmonella* in animals must bear in mind that the microbial ecology of the animal is a critical factor that must be accounted for when designing intervention strategies. Competitive exclusion, sodium chlorate, vaccination, are bacteriophage are all strategies that can reduce *Salmonella* in the live animal, but it is vital to understand how they function.

Key Words: *Salmonella*, Preharvest Strategies, Food safety

55 Current and future *Salmonella* challenges: Background, serotypes, pathogenicity, and drug resistance. S. L. Foley*, *Marshfield Clinic Research Foundation*, *Marshfield, WI*.

Salmonellosis is a worldwide health problem and *Salmonella* infections are the second leading cause of bacterial foodborne illnesses in the U.S. Approximately 95% of human salmonellosis cases are associated with consumption of contaminated foods such as meat, poultry, eggs, milk, seafood, and fresh produce. *Salmonella* can cause a number of human illnesses that include enterocolitis, bacteremia, and typhoid fever, with the most common being enterocolitis. Enterocolitis is often characterized by abdominal pain, nausea and vomiting, diarrhea, and headache. Typically the illness is self-limiting, but antimicrobial therapy is often needed to treat more severe infections. Currently, there are over 2,500 identified serotypes of *Salmonella*. A smaller number of these serotypes are significantly associated with animal and human illnesses. These include Typhimurium, Enteritidis, Newport, Heidelberg, Muenchen, and Montevideo. Isolates from these serotypes are more frequently detected demonstrating resistance to multiple antimicrobial agents, especially third generation cephalosporins that are recommended for treatment of severe infections. Many of the genes encoding resistance are located on transmissible elements such as plasmids to allow for potential transfer of resistance among strains. Plasmids are also known to harbor virulence factors that contribute to *Salmonella* pathogenicity. Several serotypes of medical importance such as Typhimurium, Enteritidis, Newport, Dublin, and Choleraesuis are known to harbor virulence plasmids containing genes encoding for fimbriae, serum resistance, and other factors. Additionally, many *Salmonella* contain pathogenicity islands scattered throughout their genomes to encode factors essential for bacterial adhesion, invasion, and infection. *Salmonella* have evolved several virulence and antimicrobial resistance mechanisms that allowed for continued challenges to our public health infrastructure.

Key Words: *Salmonella*, Pathogenesis, Antimicrobial Resistance

56 Current and future *Salmonella* challenges: Prevalence of *Salmonella* in beef and dairy cattle and potential pathogenicity of their isolates. C. R. Jackson*, P. J. Fedorka-Cray, J. Haro, and B. M. McGlinchey, *USDA-ARS*, *Athens, GA*.

Salmonella is a leading cause of foodborne illnesses that spread to humans from different sources. While all *Salmonella* serotypes have the potential to cause illnesses, certain serovars appear to be responsible for various illnesses in animals and humans. *Salmonella* Typhimurium, *S.* Enteritidis, and *S.* Newport are in the top five serotypes implicated in human infections whereas *S.* Dublin is a common cause of cattle infections. As a part of the National Antimicrobial Resistance Monitoring System (NARMS), prevalence, antimicrobial susceptibility, and pulsed-field gel electrophoresis of *Salmonella* serotypes in beef and dairy cattle collected from 1997 to 2005 were examined. A total of 10,228 and 4,584 *Salmonella* isolates from beef cattle and dairy cattle, respectively, were tested. For beef cattle, the clinical status of the isolates included slaughter (n = 6,813; 61.3%), diagnostic (n = 3,415; 30.7%), and on-farm (n = 883; 8.0%). For dairy cattle, the clinical status included diagnostic (n = 3,036; 66.2%) and on-farm (n = 1,548; 33.8%). For samples from beef cattle at slaughter, the top three serotypes were *S.* Montevideo (13.9%), *S.* Anatum (8.9%), and *S.* Newport (7.6%). For diagnostic isolates, the top three serotypes from both beef and dairy cattle were the same, but were ranked differently: *S.* Typhimurium var. 5- (15.8%), *S.* Newport (13.6%), and *S.* Typhimurium (13.1%) from beef cattle and *S.* Newport (24.3%), *S.* Typhimurium (19.7%), and *S.* Typhimurium var. 5- (18.6%) from dairy cattle. Regardless of the source, 51.9% of all *Salmonella* from cattle were pan-susceptible in 2005. Through 2005, 45.4% of *S.* Typhimurium, 24.6% of *S.* Newport, and 13.4% of *S.* Typhimurium var. 5- from slaughter samples were pan-susceptible. Multidrug resistance (resistance to two or more antimicrobials) was 80.2% for *S.* Typhimurium var. 5-, 74.8% for *S.* Newport, and 52.0% for *S.* Typhimurium. Using PFGE, the most common pattern for all cattle isolates was for *S.* Newport (n = 165). The results demonstrated the differences between beef and dairy cattle in prevalence of *Salmonella* serotypes.

Key Words: *Salmonella*, Cattle, Serotypes

57 Current and future *Salmonella* challenges: Prevalence in swine and poultry and potential pathogenicity of their isolates. S. L. Foley*, *Marshfield Clinic Research Foundation*, *Marshfield, WI*.

Salmonella infections are the second leading cause of bacterial foodborne illness in the U.S. The great majority of these infections are associated with consumption of foods such as meat, poultry, eggs, milk, seafood, and fresh produce contaminated with *Salmonella*. The per capita consumption of meat and poultry in the U.S. has increased significantly over the past century. This increase is especially evident with poultry products, where there has been a nearly six-fold increase in chicken consumption and 17-fold increase in turkey consumption since 1909. The annual per capita consumption of pork has also increased over that time from 18.7 to 21.7 kg. With these increases in consumption, the dynamics of animal production and consumer exposure have changed leading to new challenges in limiting salmonellosis. To meet the high demand of consumers, more intensive agricultural practices have been adopted. This has likely changed the population characteristics of *Salmonella* present among poultry and swine populations. With regard to *Salmonella* isolated from swine in the U.S., Typhimurium has replaced Choleraesuis as the predominant serovar in recent years. Among isolates collected from turkeys in 2004, serovars Senftenberg and Hadar were most common. However, Heidelberg was most common from clinical sources, potentially indicating increased virulence. Heidelberg was also the most commonly detected serovar in clinical and non-clincal isolates from chickens. A high percentage of isolates from many of these prominent serovars are resistant to antibiotics. Public statistics suggested that antimicrobial use in the U.S. has increased at least 30-fold over the past 50 yr. This increase has likely provided selective pressure to drive proliferation of antimicrobial resistance and potentially select for transfer of virulence factors. This can be physically associated with resistance genes that lead to increased pathogenicity among *Salmonella* strains.

Key Words: *Salmonella*, Swine, Poultry