

quality traits show opportunities for indirect measurements (Minolta, pH and conductivity), they also show possibilities for simplified measurements (drip score). Heritabilities are interestingly high. Repeated meat quality measurements will further decrease the error term and increase the effective heritability. Uniformity in meat quality can be improved by using uniform sire line\*dam cross, standardized shipping and processing, and genetic selection.

**Key Words:** Meat Quality, Variation, Heritability

**49 Using a web-based economic model to examine investment decisions in the turkey industry for both integrated and non-integrated companies.** B. J. Wood\* and N. Buddiger, *Hybrid Turkeys, Kitchener, Ontario, Canada.*

An economic model for both integrated and non-integrated turkey production companies was created for use as a web-based management tool. Modeling turkey production was possible as all variables, from the supply of parent stock (PS) through to carcass processing and sale of final product, were readily quantified. Costs of production included PS and hatching costs related to poult production, feed, housing and labor for both the poult and commercial live production and finally manufacturing costs in the processing plant. Returns were generated through the sale of processed final product. At each level manipulation of PS strain, feed, labor, housing and processing had an effect on profitability and to accurately assess the impact of each, the model should reflect the change in profitability of the system when production parameters were altered. Parameters higher in the production chain such as commercial poult cost and PS selection affected lower elements in the model such as the live production cost which ultimately affects the gross margin. Price volatility in feed and breast meat price were modeled with Gompertz-type growth and feed intake equations. This allowed optimal slaughter age or weight windows to be calculated based on feed price and processed product value. As feed price decreased or processed breast meat price increased the optimal slaughter weight

also increased, conversely, with increased feed or lower breast meat price, the opposite was true, with a decrease in the optimal slaughter weight because of lower feed efficiencies at later ages. In each case, a decision on investment in feed and facilities must be made. Economic modeling can increase profitability via the ability to identify areas in which changes in management or investment can be made to improve performance. By examining the profit to investment ratio, investment may be made in an economically rational manner with funds channeled to areas that best increase the profit to investment ratio.

**Key Words:** Economic Model, Turkeys, World Wide Web

**50 Quantitative and biological issues of feed utilization efficiency.** S. E. Aggrey\*, *University of Georgia, Athens.*

Most parametric statistical tests assume an additive rather than proportional error model. Since FC and BWG do not have similar distributions, the ratios of the two tend to be asymmetric (skewed). This violates the normality assumption the normality assumption of most statistical tests. The central limit theorem affords little protection for most skewed distributions, and when the sample size is small, the P-values associated with parametric tests like the t-test and ANOVA is incorrect. Summary statistics of FCR and FE yield different quantities. Log (any base) transformation of FE and FCR has the advantage of transforming the error model from a proportional to an additive one because  $\log(\text{FC}/\text{BWG}) = \log(\text{FC}) - \log(\text{BWG})$ . Distributions of log values and consequently log ratios tends to be normal. Summary statistics of log ratios yield the same quantities, regardless of numerator/denominator assignments. The difference in sign of the means reflects whether on average the numerator is larger [+] or smaller [-] than the denominator. Taking the antilog of the average log ratios returns the data to a fold-metric.

**Key Words:** Feed Conversion Ratio, Feed Efficiency, Log Transformation

## **Egg and Meat Science and Muscle Biology - Livestock and Poultry: Meat Packaging and Shelf Life**

**51 Overview of meat life cycle from harvest to consumer.** R. D. Huffman\*<sup>1</sup> and J. C. Brooks<sup>2</sup>, <sup>1</sup>*American Meat Institute Foundation, Washington, DC,* <sup>2</sup>*Texas Tech University, Lubbock.*

The harvest, processing and distribution of perishable meat products presents myriad challenges with respect to maintaining optimum quality and safety attributes. Frequently, the marketing term "fresh" is used to describe desirable product attributes and conversely, the term "spoiled" may be used to describe product that is no longer desirable for consumption. Product safety however is an attribute that should be decoupled from these product quality descriptors. When livestock are harvested, there exists an intrinsic potential for shelf life of the products derived from the carcass. The meat processing sector has developed numerous innovative means of protecting the integrity of raw meat products and maximizing potential shelf life of each product type. The processing steps and appropriate application of technology will determine how closely potential shelf life is maximized. This paper will describe the life cycle of meat products from the point of slaughter

to the point of consumption, and attempt to clarify the meaning of the terms "fresh" and "spoiled." The history of meat preservation dates back centuries and involves such important innovations as the first uses of salt in ancient times and the advent of mechanical refrigeration in the 1930's. No doubt, these innovations were critical to the evolution of meat preservation; however, the most important recent innovation for increasing raw product shelf life is widespread adoption of vacuum packaging. Recent innovations have enabled the processing sector to further maximize fresh shelf life. Three major factors contribute to raw meat deterioration, 1) microbiological growth, 2) oxidation of lipids and 3) enzymatic activity. These factors are not mutually exclusive and in fact may interact to ultimately determine the end of shelf life. Optimum refrigeration at critical points in the harvest process, time and temperature controls throughout processing and distribution, reduction or elimination of oxygen exposure through packaging, and reduction of UV light exposure are all control methods that will mitigate the three factors that lead to product deterioration.

**Key Words:** Meat, Packaging, Shelf Life

## 52 Defining spoilage: What is shelf life and how is it determined?

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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?

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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. Enteritidis* 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