Categorizing processing via the Meat Science Lexicon

C.C. Carr, J.M. Scheffler, and D.D. Johnson
University of Florida, Department of Animal Sciences

Introduction
Consuming any meat requires some level of processing. The process of opening or “shucking” raw oysters would yield the oyster adductor, a muscle often consumed raw, making it one of the most minimally processed muscles available from nature and consumed in the developed world. Yet, this minimal level of processing is required to consume this muscle. This was the concept behind the American Meat Science Association’s Lexicon Committee (AMSA, 2017) developing language to divide meat into two major classifications based upon its level of preparation:

1) minimal processing, and
2) further processing.

These two major classifications and subsequent subdivisions refer to the level of processing applied to meat when merchandized to the end-user. For the oyster example, opening the shell would be likened to the slaughter process in the meat industry. Removing the muscle from the shell prior to consumption would be comparable to the meat industry jargon of fabrication, which is removing meat from the carcass to cut it into smaller, more useful components. The authors of the Lexicon would recognize cutting into smaller pieces as minimal processing. Adding ingredients, smoking, cooking, and/or canning the oyster meat prior to its being offered to the consumer, would all be considered further processing.

Why Do We Process Meat?
Although very little is known about the origin of processing meat, the practice probably began soon after primitive humans realized that fire would cook and extend the keeping quality of meat and that salt is a great preservative. The ancient Egyptians and Native Americans are both credited as developers of salting and drying thin cuts of meat comparable to modern jerky (Pearson and Gillett, 1996). Immigrants to North America brought the art and science of meat processing with them from around the world to their new home country. Immigrant butchers worked with a variety of meats, unique ingredients and differing environmental and processing conditions, in their respective countries.

The local agrarian communities established in the US prior to commercial refrigeration were driven by very short periods of fresh food prior to spoiling which was available only during season and close to the source. In the times of plenty, new immigrants would put away food for the times with little. Most livestock slaughter was in the fall and early winter to maximize shelf life without refrigeration. The meat from cattle, lambs, goats, and horse were all consumed in the US, but pork was the predominant protein prior to the industrial revolution (Pearson and Gillett, 1996). Chickens came from West Africa and their meat was consumed, but were not appreciably produced and consumed in the US until after World War I (Pearson and Gillett, 1996).

Beyond the slaughter of the animal, meat is further processed to varying degrees for numerous reasons. The foremost reason is food safety. Meat is an ideal growth medium for both pathogenic and non-pathogenic microorganisms and will spoil rapidly without intervention. Refrigeration less than 7°C is an effective means to extend shelf-life and slow growth of *Salmonella spp*, *Staphylococcus aureus*, and pathogenic *E coli* (Tompkin, 1996). It is likely that early civilizations at greater latitude may have inadvertently discovered the benefit of cold storage on shelf-life and food safety, leading to seasonal harvest and the use of ice.

Implications

- All meat is processed to varying degrees, even when consumed raw.
- Meat which has had ingredients added such as salt, phosphate, or seasonings prior to being merchandized to the end user have been subjected to further, rather than minimal processing.
- Improving safety and shelf-life, honoring history, adding value and convenience, diversifying flavor, and improving sustainability are all contributing reasons why science and art combine in various meat processing applications.

Key words: minimal processing, further processing, processing subdivisions

© Carr, Scheffler, and Johnson. doi:10.2527/af.2017.0438

Source: © 2017 Benreis Wikipedia.commons.org.

Oct. 2017, Vol. 7, No. 4

19
The new settlers would process and enjoy a variety of cuts of meat and fresh sausage products soon after slaughter. A variety of salted, smoked, dried, fermented, and/or cured products were made for consuming later. These methods of further processing were used for preservation by extending shelf-life and delaying spoilage. The development of railroads and refrigeration allowed the US to evolve from a mostly agrarian society to having more urban residents. These advancements allowed consumers access to fresh food almost year round, extending fresh shelf-life, and lessening the need for further processing of perishable foods (Romans et al., 1994). Preventing spoilage is an economic advantage for producers and processors, and it also reduces the cost to consumers. Further, reducing waste improves the sustainability of the product produced (Meeker and Meisinger, 2015). Meat has since been processed not only to preserve or extend shelf-life and ensure safety, but also to add commercial convenience, enhance functionality and tenderness, improve and/or diversify flavor, and to sustainably utilize everything nature has provided (Romans et al., 1994; Carr, 2014).

An entire carcass is not easily usable and most are challenging to transport. This challenge led to the next paradigm shift in the US meat industry. In 1967, Iowa Beef Packers began cutting beef and pork carcasses at a centralized location into smaller wholesale pieces, many boneless, prior to vacuum sealing and shipping in a box under refrigeration to retail and foodservice (Pearson and Gillett, 1996; Ball, 1998; Rodengen, 2000). This greatly improved retail efficiency as it is much easier to train an employee how to properly cut steaks from a ribeye roll than to teach them how to fabricate that ribeye roll from an entire carcass. Also, centralized fabrication resulted in a greater volume of meat trimmings accumulating in one location. This ultimately resulted in the establishment of more specialized facilities downstream which only grind meat or utilize other processes to maximize value.

**Minimal Processing**

Minimal processing results in the following product categories; raw, intact; raw, non-intact; raw, offal/variety meat; and raw, lean recovered. Products in these subdivisions contain no added ingredients.

**Raw, intact**

The products of initial carcass cutting or fabrication are wholesale, sub-primal, retail cuts, and trimmings. These pieces are defined as raw, intact meat by the Lexicon. Simply trimming fat is processing to increase consumer acceptability to meet the desire for a leaner product. Size reduction into roasts, steaks, and chops allows for portion control, easier meal planning, and cookery.

**Raw, non-intact**

Intact meat includes bone-in and boneless wholesale and retail cuts and trimmings generated from cutting a post-mortem carcass into smaller, more easily used or consumed components. When intact meat is later pierced with blades it then becomes non-intact and is categorized differently due to an increased food safety risk (USDA-FSIS. 1999). This is because a pathogen present on the outside of the meat could be translocated to the inside (Gill, 1979). The most significant raw, non-intact meat products are ground and mechanically tenderized. According to NCBA, 2015, the most popular ground meat in the US is ground beef, though ground pork, chicken, and turkey all have significant market share. The strong demand for these products as compared to intact meat is driven by their lower cost, recipe versatility, and ease of preparation (Davis and Lin, 2005). In 2015, 65% of US per capita beef consumption was as ground beef (NCBA, 2015).

Beef cuts are the predominant product subjected to mechanical tenderization without added ingredients. Mechanically tenderized products are more tender than intact cuts due to physically disrupting the connective tissue proteins within the meat, but still maintain the mouthfeel of an intact steak or roast. An estimated 10.5 percent of fresh beef products sold in the United States is mechanically tenderized in over 550 processing facilities, mostly destined for foodservice (Muth et al., 2012).

**Raw offal/variety meat**

All edible offal without added ingredients was given a subdivision category within minimal processing. The subdivision includes raw organ meat and other soft tissue, edible bone, and blood. Edible offal products have been consumed extensively from animals for all of recorded history to ensure that nothing from the animal was wasted (Ockerman and Basu, 2006). Edible offal items appear as a menu option at many of the world’s finest restaurants. Consumption of organ meat and other soft tissues, blood, and rendered fat has decreased in many Western cultures in recent years (Aberle et al., 2001). However, demand for organ meat and other soft tissues is exceptionally strong outside of the US and Canada and accounts for a large percentage of US meat exports (USMEF, 2017).

**Raw, lean recovered**

The most complicated subdivision within minimal processing is the raw, lean recovered category. These products have certainly been processed, yet the proteins still have great nutritional value (USDA-FSIS 2010b). The products included in this subdivision are, finely textured meat, partially defatted meat, mechanically separated meat, and meat produced from an advanced meat recovery system. If any of the products in this subdivision have salt or nitrite added they would be recognized within the raw non-intact with added ingredients subdivision. These technologies make it possible for processors to sustainably and ethically use everything nature has provided, and ultimately reduces cost for nutritious protein (Bub et al., 2013).

Finely textured meat is only manufactured commercially in the US with beef, but the technology could be utilized in other species. As de-
scribed earlier and summarized by Bub et al. (2013), meat is cut and trimmed into pieces with a given level of external fat at the processing plant. Those pieces of external fat and remaining lean generated from this process are called trimmings (Berry, 1980). These trimmings are used to manufacture finely textured meat, known commercially as lean, finely-textured beef (LFTB; Roth, 1978) or finely-textured beef (FTB; Schaefer, James, and Rempe, 1995). To make LFTB and FTB, the beef trimmings are heated and centrifuged. This separates the lean meat from the fat, leaving a very lean meat product. The lean meat is then treated with either gaseous ammonia (LFTB; Roth, 1978) or citric acid (FTB; Schaefer, James, and Rempe, 1995), both of which are robust antimicrobials (Greene, 2012). The USDA has approved the use of both of these treatments in beef production as processing aids, and are currently not required to be labeled according to the Code of Federal Regulations (quoted in USDA-FSIS 2008), since they do not technically alter the composition of the food. These products are frozen, and distributed to ground beef manufacturers and are included at up to 20% of the final blend with traditional pieces of lean and fat in commercial ground beef production (BPI, 2012; Cargill Meat Solutions, 2012). Finely textured meat does not have to be specially labeled, because its composition is similar to hand-deboned meat trimmings (USDA-FSIS, 2012c; as summarized by Bub et al. (2013). These products are also frequently used in the production of lunch meats and sausages. Partially defatted meat is similar to the finely textured meat discussed earlier, in that it is made by melting fat at low temperatures and separating the liquefied fat from the lean with a centrifuge. Comparatively, the process to produce partially defatted meat is older, less efficient technology, which will generally have more fat remaining within the tissue. Most partially defatted meat is not exposed to an antimicrobial processing aid, as is finely textured meat (Happich et al., 1975). The remaining product can be added to patties and further processed products, but partially defatted meat must be declared on the label of the finished product to which it is added. As reviewed by Bub et al. (2013), mechanically-separated poultry and pork are made by crushing or grinding the bones, then forcing the bone and remaining tissue through a screen or sieve under high pressure, to sift out the larger pieces of bone, creating a protein batter (USDA-FSIS, 2010b). This technology is not allowed to be applied to beef products in the United States (USDA-FSIS, 2010b). Mechanically-separated pork or poultry can be mixed with other ground meats and ingredients, most likely in a fully-coked lunch meat or nugget product, but must be declared on the label. (USDA-FSIS, 2010b). Also, the USDA requires that any processed meat cannot contain more than 20% mechanically-separated pork or poultry, and any single species pork or poultry processed meat product cannot contain mechanically-separated meat product (USDA-FSIS, 2010b). An advanced meat recovery (AMR) system uses a series of belts to scrape, shave, and press meat off of the bones, but the machinery is not allowed to break or crush the bones (USDA-FSIS, 2002). An AMR system can be used for beef and pork bones, but not for poultry because the bones are too delicate and small (USDA-FSIS, 2002). As reviewed by Bub et al. (2013), beef and pork derived from an AMR system do not have to be specially labeled because they are similar to hand-deboned meat products (USDA-FSIS, 2002). Beef and pork from AMR processing are often blended with ground products derived from beef or pork trimmings for use in meat patties, and many further processed products (USDA-FSIS, 2002).

Further Processing

The types of meat products produced via further processing are raw, intact with added ingredients; raw, non-intact with added ingredients; unheated or mildly heated, not fully cooked; fully cooked; further processed offal/variety meat; and commercially sterile.

Raw, intact with added ingredients

This subdivision involves topical addition of non-meat ingredients (spices, exogenous enzymes, etc.) to intact muscles without vacuum-tumbling, typically for the purpose of seasoning or tenderization. This is
commonly done to improve the tenderness of steaks from mature cows. These products have had tropical plant enzymes or aspergillus oryzae applied to the surface to degrade connective tissue and muscle fiber components, thus reducing toughness. These enzymes are usually heat activated and subsequently inactivated at very high cooking temperatures. (Calkins and Sullivan, 2007). However, if products have been injected or vacuum-tumbled, they should be considered non-intact.

**Raw, non-intact with added ingredients**

The raw, non-intact with added ingredients subdivision includes products such as: 1) roasts, steaks, or pieces cut from marinated/enhanced uncooked meat which has had non-meat ingredients added to improve eating quality and/or safety, 2) fresh sausage and formed and shaped products which contain non-meat ingredients. No products in this subdivision contain ingredients for the purpose of curing nor have they been thermally processed.

Marinated/enhanced meat will be injected with a water-based solution or brine containing salt (sodium chloride). Salt has multiple purposes in meat processing, but is primarily used here to impart flavor. Salt has a long history as a preservative and flavor enhancer. The Sumarians are thought to be the first to preserve meat using salt as early as 3000 BC (Jay et al., 2005). The brine will also likely contain an alkaline phosphate which helps to maintain cooked meat juiciness and protect flavor. Some marinades will contain a flavoring, water soluble antioxidant, and/or a weak organic acid as an antimicrobial to improve the eating quality and/or safety of the product (Romans et al., 1994). Marination of raw meat is primarily to add flavor, and to improve juiciness when the consumer overcooks it.

The same mix of dry ingredients could be used with raw sausage as with marinated whole-muscle pieces, but more seasoning would be included in the formulation for most fresh sausage. For example, traditional American breakfast sausage is distinguished by the addition of sage and Italian sausage by the addition of fennel to the formulation. Fresh sausage would also contain salt, mostly for flavor, but also to extract some protein and change the texture of the product. Salt and friction combine to extract protein which are then coagulated during thermal processing (Romans et al., 1994). This process should be minimized when manufacturing fresh sausage. However, protein extraction and later coagulation during thermal processing is vitally important in the quality of any non-whole muscle, ready-to-eat product.

Two products used as cold binders in the United States are transglutaminase and fibrin. These binding ingredients are added to small or inconsistently shaped cuts of meat or poultry to bind or re-form them, without the addition of heat. This results in larger pieces of meat that can be used for portion-controlled cutting. Restructured or formed raw meat is recognized by USDA-FSIS as a non-intact product (USDA-FSIS, 1999). As reviewed by Bub et al., 2013, transglutaminase is a natural enzyme, and fibrin is an ingredient made from a combination of the protein fibrinogen and the natural enzyme thrombin. Commercially, transglutaminase is produced by *Streptoverticillium moharaense* bacteria, while fibrin is produced from porcine or bovine blood plasma (De Jong et al., 2001). All three of these (transglutaminase, fibrinogen, and thrombin) occur in the blood of all animals and humans. All of these products are listed as GRAS (generally recognized as safe) by the FDA (USFDA, 2012). All products made using either of these binders must labeled as “formed” or “restructured” meat and the ingredient must be listed on the label (USDA-FSIS, 2012b).

**Unheated or mildly heated, not fully cooked**

The unheated or mildly heated, not fully cooked subdivision includes meat which has not been exposed to thermal treatment beyond temperatures utilized for fermentation or partial frying. Products in this subdivision could have been dried, fermented, acidified, cured, cold-smoked, and battered and/or breaded. Some of the products within this category would be marketed to end-users as ready-to-eat, and others, not.

The most common not ready-to-eat cured item available at retail is sliced bacon which will require further thermal processing at the consumer level to be deemed safe. The same could be said for cold smoked sausage and battered and breaded products which are only partially fried. Cold smoked sausages and battered and breaded products are likely the only two products within this subdivision which would not contain nitrate or nitrite added to facilitate curing, although some cold-smoked sausages are cured. Battered and breaded products are typically coated with pre-dust or with a seasoned batter consisting of a blend of flour(s), starches and water to produce a specific flavor, texture and/or mouth-feel. Coatings adhere to the product by briefly cooking/ frying in oil, known as partial frying (par-frying), to set the coating (Romans et al., 1994; AMSA, 2017).

Ready-to-eat products would have validated safety based upon the ingredients used in combination with their level of thermal processing and other post-lethality treatments, for example high pressure processing. These
commercially sterile chemicals to hydrolyze the collagen to gelatin, which is then recovered and bone. These tissues are then either exposed to high temperatures or liquefied fat is then heated to 93ºC and centrifuged again, prior to storage.

43ºC, then centrifuged to separate the fat, moisture, and solids. The liquid rendered products are produced by grinding fat, which is then melted at tallow are derived from edible fat of pigs and cattle, respectively. These further processed offal/variety meat to a greater temperature (Romans et al., 1994; AMSA, 2017).

Fully cooked
Products in the fully cooked subdivision, are cooked and/or smoked to a pasteurization endpoint time and temperature combination. Any of the dried, fermented, acidified, cured, and battered and/or breaded meat items included above can be included in the fully cooked subdivision, if cooked to a greater temperature (Romans et al., 1994; AMSA, 2017).

Further processed offal/variety meat
The primary products recognized by this subdivision are tallow, gelatin, lard, fried pork skins (rinds), and blood and tongue sausage. Lard and tallow are derived from edible fat of pigs and cattle, respectively. These rendered products are produced by grinding fat, which is then melted at 43ºC, then centrifuged to separate the fat, moisture, and solids. The liquidified fat is then heated to 93ºC and centrifuged again, prior to storage. Gelatin is derived from collagen rich raw materials, such as animal skin and bone. These tissues are then either exposed to high temperatures or chemicals to hydrolyze the collagen to gelatin, which is then recovered and dried. (Ockerman and Basu, 2006).

Commercially sterile
The commercially sterile meat products subdivision have been processed via retorting or irradiation in a sealed container with sufficient heat or energy to achieve inactivation of spoilage and pathogenic microorganisms and/or their spores. These products are considered shelf-stable and do not require refrigeration to maintain their shelf-life (USDA-FSIS, 2010a; AMSA, 2017).

Conclusions
The Meat Science Lexicon is intended to provide consistent, valid, science-based, terminology to define, describe, and differentiate meat. All meat is processed to varying degrees, even when consumed raw. The committee differentiated between minimal and further processed meat based upon the absence or presence of ingredients, and delineated further subdivisions based upon food safety risk and level of thermal processing. These two major classifications and subsequent subdivisions refer to the level of processing applied to the meat when merchandized to the end-user. This will be a living document updated by the committee with the intention to consistently define the extent which meat has been processed.

Literature Cited
Aberle, E. D., J.C. Forrest, D. E. Gerrard, and E. W. Mills. 2001. By products of the meat industry. In Principles of meat science. Kendall-Hunt, Dubuque, IA.
AMSA. 2017. American Meat Science Association. Lexicon for meat science & technology allied fields. Seman, D. L., D. D. Bolet, C. C. Marr, M. E. Dikeman, C. M. Owens, J. T. Keeton, T. D. Pringle, J. J. Sindelar, D. R. Woerner, A. S. de Mello, and T. H. Powell. Accessed June 2017. http://meatscience.org/publications-resources/printed-publications/meat-science-lexicon/lexicon-meat-science-lexicon
Ball, C. E. 1998. Building the beef industry: a century of commitment 1898-1998. National Cattlemen’s Foundation, Centennial, CO.
Berry, B. W. 1980. Effects of Chopping versus Grinding on Palatability, Shear, Chemical and Cooking Properties of Beef Patties. J. Anim. Sci. 51:615-9.
Bub, E. L., K. Schneider, C. C. Marr, and M. Herson. 2013. Food Processing: The Meat We Eat. EDIS, UF/IFAS. Accessed June 2017. http://edis.ifas.ufl.edu/an283
Beef Products, Inc. (BPI). 2012. “Simply Beef.” Accessed June 2017. http://www.beefproducts.com/simply-beef/
Calkins, C. R. and G. Sullivan. 2007. NCBA White Paper. Adding enzymes to improve beef tenderness. Accessed June 2017. http://www.beefresearch.org/CMDocs/BeefResearch/PE_Fact_Sheets/Adding_Enzymes_to_Improve_Beef_Tenderness.pdf
Cargill Meat Solutions. 2012. “About Finely Textured Beef.” Accessed June 2017. http://www.cargillgroundbeef.com/learn-textured.aspx
Carr, C. C. 2014. Coursena. The Meat We Eat. Transcribed audio from Massive Online Course. Accessed June 2017. http://www.coursenaa.org/learn/meat-we-eat/lecture/300thxan/us-history
Davis, C. G., and B. H. Lin. 2005. Factors affecting U.S. beef consumption. USDA ERS Research Report LD0-M-135-02. USDA ERS, Washington, DC.
De Jong, G.A.H., G. Wijngaards, H. Boumans, S. J. Koppelman, and M. Hessing. 2001. “Purification and Substrate Specificity of Transglutaminases from Blood and Streptococciellum mohurense.” J. Agric. Food Chem. 49:3389-93.
Gill, C. O. 1979. “Intrinsic Bacteria in Meat.” J. Applied Bacteriology 47:367-78.
Greene, J. L. 2012. “Lean Finely Textured Beef: The ‘Pink Slime’ Controversy.” Congressional Research Service, USDA. Accessed November 2012. http://www.fas.org/spp/ers/nisce/RS42473.pdf
Happich, M. L., R. A. Whitmore, R. Fearheller, M. M. Taylor, C. G. Swift, J. Naghashi, A. N. Booth, R. H. Alsmeyer. 1975. Composition and protein efficiency ratio of partially defatted chopped beef and of partially defatted beef fatty tissue and combinations with selected proteins. J. Food Sci. 40, 35.
Jay, JM, M.J. Loessner, and D.A. Golden. 2005. Modern Food Microbiology. Springer Science, New York, NY.
Keeton, J. T. 2011. History of nitrite and nitrate in food. In Nitrite and Nitrate in Human Health and Disease, edited by Nathan Bryan and Joseph Loscalzo, 69-84.
New York: Humana Press, Springer Science+Business Media LLC. 
doi:10.1007/978-1-4607-5-416-0.

Meeker, D.L. and J. L. Meisinger. 2015. Rendered ingredients significantly influence sustainability, quality, and safety of pet food. J. Anim. Sci. 93(3): 835-47.

Muth, M.K., M.B. Michaela, & C. Cogliati. 2012. Expert elicitation on the market shares for raw meat and poultry products containing added solutions and mechanically tenderized raw meat and poultry products. Accessed June 2017. http://www. fsis.usda.gov/wps/wcm/connect/3a97f0b5-b252-4222-b387-e6eae60708c11/Hot_Dogs_and_Food_Safety.pdf?MOD=AJPERES

NCBA. 2015. Usage and volumetric assessment of beef in foodservice 2015. Accessed June 2017. http://www.welovebeef.com/CMDev/BeefResearch/MR- Presentations/Beef_Volumetric_2015.pdf

Ockerman, H.W., and L. Basu. 2006. Edible rendering- rendered products for human use. Editor- D.L. Meeker. Kirby Lithographic Company, Inc. Arlington, Virginia

Pearson, A.M. and T. A. Gillett. 1996. Processed meats. 3rd Ed. Chapman & Hall, New York, NY

Rodengen, J. L. 2000. The Legend of IBP. Write Stuff Enterprises. Ft. Lauderdale, FL.

Romans, J. R., W. J. Costello, C. W. Carlson, M. L. Greaser and K. W. Jones. 1994. The meat we eat. Danville, IL: Interstate Publisher, Inc.

Roth, E. 1978. Method for forming frozen meat patties. US Patent 4192899, filed September 11, 1978, and issued March 11, 1980.

Rust, R. E. 2007. US products. In Handbook of Fermented Meat and Poultry, edited by Fidel Toldra, First edit, 303-6. Hoboken, NJ: Blackwell Publishing.

Schaefer, D.L., R. M. James, and M. E. Rempe. 1995. Low temperature rendering process. US Patent 5725897, filed July 25, 1995, and issued March 10, 1998.

Tompkin, R.B. 1996. The Significance of time-temperature to growth of foodborne pathogens during refrigeration at 40-50°F. Presented during the Joint FSIS/FDA Conference on Temperature. November 18, Washington, DC. Accessed June 2017.

https://meathaccp.wisc.edu/Model_Haccp_Plans/assets/raw_ground/TomkinPaper. pdf

USDA-FSIS. 1999. “FSIS Policy on Non-Intact Raw Beef Products Contaminated with E. coli O157:H7.” Accessed June 2017. https://www.fsis.usda.gov/Oa/background/O157policy.htm?redirecturl=true

USDA-FSIS. 2002. Revised Directive for Advanced Meat Recovery Systems. Accessed June 2017. https://www.fsis.usda.gov/Oa/background/amadirect.htm

USDA-FSIS. 2008. Compliance Guide on the Determination of Processing Aids. Accessed June 2017. https://www.fsis.usda.gov/wps/wcm/ connect/9a34e8d9-997a-4e58-bd5e-d87ec371e0ca/Determination_of_Processing_ Aids.pdf?MOD=AJPERES

USDA-FSIS. 2010a. Canning. Accessed June 2017. http://www.fsis.usda.gov/OP-PDE/rdad/FRPubs/97-013N/Puhlser_Canning.pdf.

USDA-FSIS. 2010b. Meat Preparation: Hot Dogs and Food Safety. Accessed June 2017. https://www.fsis.usda.gov/wps/wcm/connect/6862410d-e659-41ee-82c7-6eae60708c11/Hot_Dogs_and_Food_Safety.pdf?MOD=AJPERES

USDA-FSIS. 2012a. FSIS Product Categorization. Accessed June 2017. https://www. fsis.usda.gov/wps/wcm/connect/a2c5f828-68d4-4e43-9c0f-a3cd482868b4/FSIS_Product_Categorization.pdf?MOD=AJPERES

USDA-FSIS. 2012b. Safety of Transglutaminase Enzyme (TG enzyme). Accessed June 2017. https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/food-labeling/safety-of-transglutaminase-tg-enzyme

USDA-FSIS. 2012c. Setting the record straight on beef. Accessed June 2017 https:// www.usda.gov/media/blog/2012/03/22/setting-record-straight-beef

United States Food and Drug Administration (US FDA). 2012. “Generally Recognized as Safe (GRAS).” Accessed June 2017. https://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/SCOGS/default.htm

USMEF. 2017. United States Meat Export Federation. Statistics. Accessed June 2017. https://www.usmef.org/news-statistics/statistics/

About the Authors

Chad Carr grew up in Bethpage, TN on a diversified livestock operation, which included purebred Hampshire hogs and commercial beef cattle production. He received his B.S. and M.S. in animal science at Oklahoma State University and a Ph.D. in animal science at the University of Missouri where his primary research focus was improving fresh meat quality. As an Associate Professor, his duties at the University of Florida (UF) include undergraduate teaching within the Department of Animal Sciences and coordinating food safety trainings for meat and poultry processors within the state. Carr works to provide educational programs in meat and livestock evaluation to youth, niche marketing strategies to livestock producers and meat processors, and meat quality training to Florida’s extensive food service industry. His teaching responsibilities also include coordinating the intercollegiate judging programs for meat and livestock and mentoring graduate students. Also, more than 50,000 consumers worldwide have taken UF’s consumer meat education class, “The Meat We Eat,” as a Massive Open Online Course via the Coursera platform. Carr and his wife Cathy and daughters Ella and Rose live in Micanopy, FL.

Dr. Jason Scheffler is an assistant professor in the Department of Animal Sciences at the University of Florida. He earned his M.S. in Growth Biology and Meat Science from Michigan State University and a PhD in Muscle Growth and Development at the University of Nebraska–Lincoln. After a post-doc at Purdue University, Scheffler worked as a research assistant professor at Virginia Tech University and joined the University of Florida in 2014. His current extension responsibilities include coordinating HACCP and preventive controls for animal food training programs. He teaches “Introduction to Animal Science” and is co-instructor for HACCP systems, and meat technology courses.

Dr. Dwain Johnson has more than 30 years of experience in all phases of the meat industry. He obtained his B.S. in animal science at Texas A&M University in 1976, a M.S. from Oklahoma State University in food science in 1978, and a Ph.D. in meat science and muscle biology at Texas A&M in 1984. Later that year, he joined the faculty of the Department of Animal Sciences at the University of Florida. He spent the next 32 years as a professor of meat science involved in teaching and research, prior to his retirement in 2016. His research focused on ante- and postmortem factors influencing animal composition and meat palatability, and he produced more than 200 publications with more than 90 being in refereed scientific journals. Some of his most well-recognized research identified undervalued portions of the beef carcass. The work of he and his coworkers resulted in the development of the “flat-iron” steak, currently the US’s fifth best-selling beef item. As a result of his contributions to the meat industry, Johnson has been recognized by Oklahoma State University, the American Meat Science Association, and the International Meat Secretariat, for his professional accomplishments.