PROCESSING POULTRY PRODUCTS *

INTRODUCTION

Poultry meat production, processing, and distribution have undergone many changes during the past 50 years as a result of consumer demand for poultry products. The National Chicken Council (NCC) estimated that in 1962, 83 % of chicken marketed in the U.S. was sold as whole birds, 15% of chicken marketed was cut-up parts and only 2% of the market was further processed products. In 2015, the NCC estimates that only 11% of the market will be whole birds, 40% will be cut-up parts and 49% of the chicken marketed in the U.S. will be further-processed products. Today, there is a great deal of diversification in the poultry products that are marketed and it is this diversification of product lines that has helped the industry to meet consumer demands as well as remain competitive with other meat industries. While significant changes have occurred in the market segments over the years, one thing that has remained constant is the need to convert a live animal into a safe, wholesome food product for human consumption, regardless of what the final product is. The Food Safety and Inspection Service (FSIS) of the USDA is the regulatory agency that oversees poultry processing. The Poultry Products Inspection Act enforced by the USDA and the Pathogen Reduction Act enforced by the FSIS defines the guidelines for poultry processing in the United States.

In a vertically integrated poultry meat processing operation, considerations begin well before the birds are brought to the processing plant. The genetic strains are carefully selected and bred, feed is properly selected and formulated, and housing conditions are closely monitored and maintained at appropriate conditions to enhance growth and reduce stress in the birds. Excessive stress applied on the birds at the farm or before processing may affect the quality of the meat produced. Additionally, a poultry veterinarian from the integrated company closely supervises flock health to control disease and dispose of untreatable birds. Birds are humanely cared for throughout their production and at the processing plant.

BASIC STEPS IN POULTRY PROCESSING

Chickens are marketed in a variety of market ages/weights depending on the end product. Most can range from 28 to 60+ days with weights of 3.6 pounds to over 7.5 pounds with the lighter weight chickens being the youngest. Typically, the lighter weight chickens are used for fast food and whole bird operations while the heavier birds are used more in further processing. Female turkeys are processed at 14 to 16 weeks of age, while the larger males are approximately 18 to 20 weeks old. The same general processing scheme is used for both turkeys and chickens. The basic steps are discussed briefly in this section. This image depicts a grading and processing line at KFC, Inc.

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The first step in processing is the "withdrawal" of feed and controlled delivery of drinking water available to the chickens. Feed withdrawal is the length of time that birds are held without feed in the 24-hour period before processing. Usually, feed is removed first and water is removed in the last hours before catching. The process consists of raising the feeders above the reach of the birds at 8 to 12 hours for chicken broilers, or 8 to 10 hours for turkeys, before processing. Ideally, water is withheld for the last four hours before processing. The feed withdrawal period is necessary because it helps to clear feces from the lower part of the intestine. Limiting the amount of fecal matter in the intestine reduces contamination during processing, especially during the evisceration step. This practice plays a role in reducing contamination with pathogens such as *Salmonella* in poultry meat.

In the next step, the birds are caught and loaded into coops or crates for transport to the company-owned processing plant. Generally, the ride to the processing facility takes no more than 2 to 3 hours. The lengths of the transportation and holding times at the facility must be considered along with the time window for feed and water withdrawal. A shorter ride (~1 hour) is ideal as it limits the time that the birds are exposed to hot summers and cold winters decreasing exposure to potentially stressful environments. Catching can either be completed by a trained catch crew or by automated catching equipment. Manual catching crews are well trained in the proper catching procedure to prevent injury to people and the chickens. Automated catching equipment has been developed and consists of small vehicles that attach to transport coops. A series of rotating rubber fingers move right above the floor level and collect birds onto a conveyer belt where they are moved into the coops. Manual catchers and automated catchers are closely monitored to avoid injury during the catching process. It is critical to not injure the birds during catching due to animal welfare issues and because bruises and broken bones result in lost yield from the flock. After catching, coops are loaded on commercial trucks driven to the processing facility which are generally located within a close proximity to the farms. At the processing facility, the birds are held under ventilated sheds while they await their turn to go into the plant. Careful coordination is required to limit the time that the birds are held on the trucks before they go into the plant and to fulfill feed and water withdrawal time requirements. Birds are slowly removed from the transport coops onto a conveyor belt that takes them into a dark room to be loaded on processing shackles. The room is dimly lit to help calm the birds so that workers can more easily manually hang the birds on the shackles. Shackled birds are then mechanically conveyed into the processing facility.

After hanging, birds are stunned to render them unconscious before slaughter. In the U.S., typically the stun is delivered using a carefully monitored electrical current. Shackled birds are conveyed through the stunning area so that the head of the bird is in contact with a saline bath through which the current is delivered. Enough current passes through the saline water to render the birds unconscious, but it does not kill them. An alternative stunning method incorporated in certain facilities, consists of exposing birds to a gas mixture (carbon dioxide based) while the birds are held in the coops. This process renders the bird unconscious as carbon dioxide is an anesthetic gas. Because the birds are unconscious, stress during hanging on shackles is eliminated. Irreversible stuns can also be used in gas-stun facilities where the percentage of carbon dioxide is high resulting in asphyxiation of the birds due to the displacement of oxygen.

After stunning, unconscious birds go to an automatic cutting machine that cuts one or both sides of the neck, severing the jugular vein and carotid artery. The bird is then allowed to bleed (i.e., exsanguination) for approximately two minutes. Cutting must be carefully calibrated to avoid severing the spine, so that brain functions are not compromised. Continuous brain activity allows the pumping heart to assist in better bleeding of the bird.

The next step is scalding, which loosens the feathers so that they can be easily removed during defeathering (picking). Shackled birds move along the processing line and travel through an aerated hot water bath. The hot water denatures the proteins of the feather follicle (i.e., breaks down muscles holding the feathers) to ease feather removal by the automated picking machine. Temperature of scald water can vary dependent on how the final product is to be used. Hotter temperatures remove the yellow pigment and provide a whiter-looking skin commonly preferred by most U.S. consumers. Scalding parameters can also vary some depending on the systems used. Poultry carcasses are immersed in 138ºF to 140ºF water for 30 to 75 seconds (batch-type system, small scale processing) to be hard-scalded. This hard-scald removes the waxy cuticle, or outer layer of epidermis and is typically used for birds that will be breaded with a water-based batter because removal of the cuticle allows for improved batter adhesion. Therefore, fast-food restaurants commonly use birds that have been hard-scalded. In certain regions of the U.S., the cuticle is generally left on birds that are sold in the retail market as some consumers prefer the yellow color provided by the pigments retained in the cuticle. These birds are soft-scalded at 123ºF to 130ºF for 90 to 120 seconds (batch-type system), a process that minimizes the removal of the cuticle layer of the skin. In a continuous system where birds are on shackle lines traveling through the scalder (industry, large scale processing), temperatures can range from 120ºF to 136ºF for a period of two to four minutes. Because scalding is a time- and temperature-dependent process, the combination of time and temperature can vary depending on results desired (hard or soft scald). For example, a shorter time combined with higher temperatures could result in a hard-scald. Furthermore, multiple tanks can be used in continuous flow systems and therefore, temperatures can vary from tank to tank, all dependent on desired results. Following scalding, birds are taken to the pickers or defeathering machines. Feather removal is completed by rubber fingers that pull the feathers from the carcass. After picking, the birds are carried through a bank of flames that remove any remaining filoplumes or hair-like structures on the carcass, a process known as singeing.

Next, the birds are transferred from the slaughter line to the evisceration line, as shown in this OSHA image. First, an automatic hock cutter removes the hocks and then birds are rehung by the end of the drumstick using automated equipment. Chickens are hung using a two-point hanging system that shackles the carcass by the drumsticks only. Heavier turkeys often use a three-point hanging system that shackles the hocks and the neck.

After rehanging, the oil or preen gland is removed from just above the tail and then the birds travel to the evisceration area. During evisceration, a continuous series of machines automatically open the body cavity and remove the viscera, or internal organs. The machines must be properly adjusted so that the cut is carefully made and the viscera are not torn during the proce-

dure. A rupture of the intestinal contents may cause the remaining fecal material to be released, and cross-contamination may increase bacterial levels in the carcass. Cross-contamination can also increase the likelihood of *Salmonella* positive carcasses, considering that this organism is commonly present in fecal material. In turkey processing, turkeys are manually eviscerated due to their increased size. The three-point hang aids in this process as the carcass hangs in more of a horizontal position, thereby easing the evisceration process for the plant worker.

The USDA requires that the viscera remain with the bird for inspection by a USDA inspector. This inspection is paid by the U.S. government, and no meat can be commercially marketed in the country without USDA inspection. The FSIS branch of the USDA inspects every bird processed in the United States. The inspector is specially trained to look for disease or contamination that may make the bird unwholesome. It is important to remember, however, that the organisms (such as *Salmonella*) that make people sick cannot be seen by the naked eye. Therefore, processing plants must have an effective food safety system in place to control pathogenic bacteria from the farm through processing and distribution. A commonly-used plan for controlling and monitoring food safety is known as the Hazard Analysis and Critical Control Point (HACCP) system. This is a preventive plan that monitors the most critical steps during processing to minimize pathogen contamination and other hazards that may be associated with poultry products.

After inspection, the giblets, which include the heart, gizzard and liver, are removed and sent to another line for further washing, chilling, and packaging. After carcass inspection and giblet removal, the carcasses are washed a final time to remove any adhering material. During or after the final washing, a relatively recent step may be incorporated into the traditional poultry processing scheme. The application of an antimicrobial wash or rinse on the surface of eviscerated carcasses, as shown in this image provided by Auburn University, has been in use since about the year 2000 after being implemented by the Pathogen Reduction Act. The treatment is aimed at reducing or inactivating microbial organisms, specifically *Salmonella* cells. The incidence levels of *Salmonella* must be maintained at levels below 10% (10 out of 100 birds tested) to pass FSIS inspection. Therefore, the antimicrobial wash or rinse treatment assists processors in fulfilling regulatory requirements. The most common used antimicrobials include chlorine derivatives, organic acids, and other acidic components. This is a developing area and several products or product mixes have been recently released for use.

Reducing carcass temperature is a critical step in poultry processing. Birds must be chilled below 40ºF within 4 to 8 hours, depending on the carcass weight. The USDA specifies the exact times and monitors its fulfillment. The main objective is the cooling of the meat to minimize bacterial growth. In the U.S., chilling is typically achieved in a water immersion chill tank. During immersion chilling, birds are placed in a 50-60F water bath for approximately 15 minutes (pre-chill) followed by a 34ºF water bath for up to 105 minutes, depending on bird size. Chill tanks maintain a counter-current flow where cold water is added into the chill tank near the exit of the tank; therefore, as carcasses move through the tank they are always moving towards cleaner, colder water. An alternative chilling process most commonly used in Europe and Canada is

known as air chilling. The water immersion tank is replaced by an air chilling room that cools the bird by the use of cold air drafts. This air chill process takes a longer time compared to immersion chilling because it is less efficient due to the medium used (air vs. water). Only a few facilities in the U.S. are currently applying the air chilling process with relative success. There are several arguments comparing the pros and cons of these technologies; however, the main objective of cooling the birds is properly achieved by both methodologies. Concerns such as water retention, bacterial cross-contamination and water usage are associated with water immersion chilling, while efficiency, costs, and yields are common problems associated with air chilling.

After chilling, carcasses are either stored for aging or taken into the further processing. To maximize product shelf-life, cut-up rooms are maintained at low temperatures to inhibit bacterial growth. Here, the carcasses are manually or automatically cut into the various parts to meet costumer (retail or foodservice) specifications, as shown in this O*Net image. For example, each fast-food operation has specific cuts and weight requirements for each carcass piece. Additionally, breast muscles are removed from the carcass and sold as boneless breast fillets and chicken tenders. The deboning of breast muscles is accomplished with either trained employees cutting the carcasses by hand, or by automated breast deboning machines. Beyond deboning, the breast meat may be further portioned into pieces of specific size and/or weight. Portioning can be done with water jets, band-saw blades, or by hand trimming.

Following cut up, the meat is moved into the packaging area. Here the parts are weighed, packaged, and placed into shipping containers for distribution. Most raw chicken sold in retail markets (i.e., grocery stores) in the U.S. is sold as fresh chicken that must be shipped quickly to the store and maintained under refrigerated conditions. This product is usually packed in Styrofoam trays with a oxygen permeable plastic overwrap. To extend shelf life, the products travel through a blast freezer for a short period of time so that the top quarter-inch of the product is frozen, a process known as crust freezing. This helps to insulate the product as it goes through the distribution and marketing. Other products are quickly frozen (and sold as frozen) to maximize shelf-life.

Most whole carcasses or product trays are graded, but grading is optional. USDA grades, definitions, and standards of identity or composition are described by the U.S. government in the Mandatory Poultry Products Inspection Act. Grades, definitions, and standards define the product to the consumer. Grading is conducted at point of cut-up or packaging by USDA AMS (Agriculture Marketing Service) federally licensed graders who are paid by the company. Grades will be indicated on the product with a USDA AMS shield (i.e., "USDA Grade A"). Grading aids the consumers in selecting poultry products because products are graded based on product quality. Typically, Grade A products (the highest quality grade) will be seen in retail cases. Lower quality grades will be used in further processed products where product grade does not affect the final product quality (i.e, breaded breast fillet). Grading can also be conducted internally by company employees, but a USDA AMS shield cannot be assigned to these products. Historically, products commonly carried USDA grades and these grades were used as a marketing tool. However,

due to the market changes (how birds are marketed) and the costs of USDA grading to the company, many companies use internal graders as a way to sort product. Whether product is USDA graded or internally graded, the objective is to still provide the highest quality product to consumers. Typically, whole birds and parts sold in the retail cases will fit the high quality grades described by USDA, regardless if a grade shield is used or not.

The FSIS-USDA has regulations on labeling terms. Some terms relate to the temperatures that chicken meat can reach during shipping. The following labeling requirements must be met. If the meat has never been held below 26ºF, it can be labeled as "fresh." If it has been held between 0ºF and 26ºF, it can be labeled as "hard chilled" or "deeply chilled." Meat that has been held below 0ºF must be labeled either "frozen" or "previously frozen."

Finally, packaged poultry products are distributed. They are transferred to refrigerated trucks that transport the products to retail stores. Refrigeration maintains product quality and minimizes bacterial growth. After the packaged poultry products reach the grocery store, local regulations determine storage temperatures for raw meat. It is critical that all raw meat be maintained at 40ºF or below to limit the growth of pathogenic bacteria as well as spoilage bacteria so that shelf life can be extended.

SUMMARY

Poultry processing has evolved in the past few decades into a highly synchronized sequence of steps that maximize production at a significant speed. From withdrawal of feed from the live bird to packaging and distributing the processed poultry meat product, the overall goal is to minimize costs while providing a high-quality, wholesome product to benefit consumers and support producers.