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Small-Scale Poultry Processing

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In order to sell poultry meat products, they must be processed in a way that results in a quality and economically viable finished product while taking into account animal welfare and environmental impact. This publication explains the poultry slaughter process step by step and some of the factors that affect final carcass quality. This guide also covers equipment needs, waste product management, and packaging needed to get poultry meat to market.

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Photo: NCAT

Introduction

A growing number of small producers are raising poultry outdoors on pasture, processing the birds on-farm, and selling the meat directly to customers at the farm or at a farmers market. Many states allow up to 1,000 birds to be processed on a farm each year and sold directly to consumers with no inspection. Some small producers are going further—building government-licensed processing plants to supply regional or niche markets. Specialty "religious kill" is often done in small plants.

Access to processing is a critical issue for small producers. Consolidation in the meat-processing industry has left very few small plants that will do custom poultry processing. (Large plants generally don't process for small producers; they can't keep track of a small batch of birds and can't make money on small-volume orders.)

This publication covers small-scale processing, both on-farm and in small plants. Relevant information on large-scale processing is also included for comparison, to provide context, and because small processors need to have some understanding of how large-scale processing works.

During the first part of the 20th century, poultry was sold live to consumers who did their own processing. In the 1930s, only the blood and feathers were removed ("New York dressed").

Table 1. Comparison of Types of Processing

	On-farm	Small	Large
Size	Outdoor or shed facility	2,000 to 3,000 sq. ft.	150,000 sq. ft.
Equipment	Manual	Manual/Mechanical	Fully automated
Cost	Less than $15,000	Less than $500,000	$25,000,000
Labor	Family	Family/hired	Hired
Capacity	50-100 birds per day	200-5,000 birds per day	250,000 birds per day
Operation	Seasonal; 1-30 processing days per year	Seasonal or year-round; 50-plus processing days per year	Year-round; process daily
Marketing	Product sold fresh, sometimes frozen; whole birds	Fresh and frozen, whole and parts	Mainly cut-up, sold fresh, further pro- cessed
Comments	Independent operation; labor-intensive; low-risk; usually non-inspected, direct sales	Independent or part of a collaborative group; requires good markets and grower commitments	Part of an integrated operation including grow-out, processing, and marketing

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As consumers demanded more convenience, the market grew for eviscerated or ready-to-cook (RTC) birds.

Producing ready-to-cook poultry involves:

- Pre-slaughter: catching and transport
- Immobilizing, killing, and bleeding
- Feather removal: scalding, picking
- Removal of head, oil glands, and feet
- Evisceration
- Chilling
- Cut-up, deboning, and further processing
- Aging
- Packaging
- Freezing
- Distribution

Pre-slaughter

Broilers are usually processed when they reach 4.5- to 6-pound live weight. Feed is withheld for eight to 12 hours before slaughter to reduce the amount of feed in the gut and the possibility of tearing it during processing, which would cause fecal contamination of the carcass. However, withholding feed for too long will result in added stress and watery guts that have the potential to leak.

Catching and Loading

Large producers harvest all their birds at once (all-in, all-out). Small producers often "skim" by harvesting larger birds and leaving smaller ones to grow. Birds are best caught at night or early in the morning. Catching when it is dark out can help reduce stress and related fatalities. For small producers, picking birds up individually by the sides is the best way to minimize stress and prevent injury. In large-scale production, chickens are caught by grabbing both legs just above the feet. No more than three birds should be carried in one hand. Crews of 10 people catch and crate birds at the rate of 10,000 per hour, bruising up to 25% of them (Barbut, 2002). In Europe, automatic harvesting machinery is increasingly used in large operations because it is considered more humane than the rough treatment by catchers who handle several birds at once.

A typical crate can hold about eight birds, depending on their size and on the weather. Crates usually have a small opening to help prevent escape during loading, but this can increase the chance of physical injury to wings. Crowding birds in crates can lead to unnecessary stress, which can have an effect on overall meat quality.

For proper sanitation, crates should be made out of plastic or metal. Used crates are sometimes available at lower prices, but should be thoroughly sanitized before use. Small producers sometimes make their own wire crates from welded wire mesh and clips.

Transport, Holding, and Unloading

Avoid holding birds in crates for too long or transporting them when the weather is too hot, cold, or wet. With on-farm processing, there is little or no travel time. If you have to transport in cold, wet weather, be sure to cover the birds. Small producers typically cover the crates with a tarp.

You will need a full-size pick-up or larger truck—200 birds in 25 crates weigh about 1,250 pounds. For more birds, you will need a trailer. If you need to transport 1,000 birds at a time, you'll need a special vehicle such as a bob truck. Coops can be stacked on a flatbed truck or trailer and secured using ratchet straps. Birds can be allowed to roam in the back of a covered trailer; however, this is usually not encouraged as injuries can occur at a higher rate.

Once the birds reach the processing facility, it is important to keep them comfortable in the holding area. Scheduling arrival at the plant can reduce waiting time. On-farm processors usually hold crated birds under trees or other shade. The conventional industry typically produces birds within one hour of the processing plant. With two hours of travel, shrinkage or weight loss is about 1% (Tanner, 1969). After two hours of travel, mortality can occur. Companies are fined for arriving with dead birds. Large processors keep crated birds in a holding shed with fans and misters to keep them cool.

Care must be taken when unloading the birds from the crates to prevent bruises and broken bones. On-farm and small plants unload birds by hand. At large plants, broilers are unloaded onto conveyor belts. Transport crates should be washed and sanitized thoroughly after each use.

Catching, loading, transporting, and unloading expose birds to new environments and new sources of stress. This can negatively affect meat quality (see Aging section). During hauling, in particular, birds have to deal with heat or cold, feed and water withdrawal, motion, vibration, noise, and social disruption (Barbut, 2002).

Birds are crated and transported to processing in this trailer. Photo: NCAT

Immobilizing, Killing, and Bleeding

Small processors usually place birds in funnel-shaped kill cones after removing them from crates; large plants hang them on shackles and stun them before killing.

For on-farm processing, stainless steel kill cones, wrapped metal, or traffic cones are commonly used. Cones can also be made by removing the bottom of a bucket or jug and attaching it to something solid. Birds are not stunned before killing and will jerk a lot during bleeding. Cones should be the proper size, and the bird's wings folded down when inserted, to prevent the bird from flapping its wings or backing out of the cone. Wing flapping can cause hemorrhages in the muscle and broken bones (Barbut, 2002). In large plants, birds are hung on shackles in a dark room to help calm them and ease handling. Special lighting, such as blue, will also keep them calm

An overhead track is used to move carcasses through a plant. Keeping birds on-line throughout killing and dressing reduces labor since there is no handling. In many small plants, the operator pushes the shackle along; in large plants, the track is motorized.

Mounted stainless steel kill cones. Photo: NCAT

and prevent flapping and injury (Barbut, 2002).

There are several ways of cutting blood vessels in poultry, the most common killing method. In the conventional industry, the carotid arteries and the jugular veins are cut on both sides of the neck by a deep cut in the front. In kosher and halaal slaughter, only one side of the neck is cut, so the birds bleed more slowly. The spinal cord should not be cut (as when the head is cut off) because the feathers "set" and are hard to pick (Sams, 2001). The esophagus should also not be cut, to prevent microbial contamination from leakage.

Stunning

Stunning is not used in on-farm processing and is only sometimes used in small plants, where it is often impractical. In some specialty religious processing, such as kosher and halaal, stunning is not permitted. However, stunning is very helpful when working with turkeys or geese because of their larger size. When using a stun gun, it is critical to set it at the correct voltage—110 volts. If you do not adjust the stun correctly, birds will be over- or under-stunned. Over-stunning will result in hemorrhages and broken bones.

Stunning is the norm at large plants. It immobilizes the birds for the killing machine, provides a uniform heartbeat for better bleeding, and relaxes the feather follicles for easier picking (Owens, 2001). Furthermore, stunning is considered more humane than not stunning. U.S. law requires stunning of other livestock, though not poultry.

In large plants, stunning works as follows. The heads of the birds are dipped into a saline bath with an electric current, rendering them temporarily unconscious (one to two minutes—enough time for cutting and bleeding them to death) (Owens, 2001). The current is low-voltage and low-amperage (about 20 volts, depending on bird size, for three to five seconds; the amperage is 10 to 12 mA per bird) (Owens, 2001).

There are relationships between stunning, killing, muscle metabolism, and meat quality. These interactions have been studied mostly with stunned birds killed in shackles because that is the typical practice in large plants. Less is known about the effects on meat quality of killing in cones with no stunning.

Bleeding

Small processors usually believe that the bleed-out is more thorough with no stunning. About 35% to 50% of the blood comes out of stunned birds, with the rest remaining mainly in the organs (Barbut, 2002). Bleeding takes one and one-half to three minutes (Owens, 2001). According to industry thought, if the bird is not stunned, the bleed-out is slower and not as complete because the bird is struggling and its organs are using blood. Maximum drainage of blood is desirable so there won't be dark spots on the meat, especially on wing veins.

On the farm, blood is collected in a bucket or trough and used in composting; however, on a large scale, blood is a wastewater pollutant since it contains a lot of organic matter. On a shackle line, blood can be collected in a blood tunnel that reduces splashing.

Feather Removal

Scalding

Small processors remove the birds from the killing cones for scalding. In large plants, the birds stay on the shackles.

Birds are scalded (immersed in hot water) to loosen the feathers. Heat breaks down the protein holding the feathers in place (Sams, 2001). Scalding is a very temperature-sensitive process.

In the United States, a hard scald is used by small

A typical scalder that can handle four to six birds at a time. Photo: NCAT

and large processors alike. It loosens the outer layer of skin, providing a better coating adhesion for fried foods (important for further processing). After a hard scald, the skin must be kept moist and covered or it will discolor. A very hard scald is needed for waterfowl because their feathers are harder to loosen.

In Europe, soft-scalding is more common and used in conjunction with air-chilling (see the Air-chilling section on page 9). The *Label Rouge* program in France, which focuses on gourmet meat quality, requires a soft scald. The skin remains intact and skin color is retained; however, picking is more difficult.

Scalding increases the body temperature of the carcass. In kosher processing, the bird is not scalded because it would partially cook the meat. As a result, the birds are harder to pick.

On-farm processors use a single tank of hot water, usually scalding one to four birds at a time. Labor is saved when a mechanism such as a basket or arm dunks several birds together. In small plants, scalders with such a mechanism can handle 12 birds at once. Some on-farm processors add dish soap to the scald water to help it better penetrate the feathers and facilitate picking; others do not find this necessary.

It can take a while to heat the water in a small scalder to the right temperature, and it can be tricky to maintain that temperature, especially when fresh water is added. Most on-farm processors don't replace the water during processing for these reasons. However, this can lead to contamination problems. Some on-farm processors solve the dilemma by using two scalders at a time, rotating them as one reaches the correct temperature. Some large scalders have an overflow to add fresh water continuously.

Additional precautionary measures can reduce filth in the scalder. Wet birds in the field can pick up manure on the skin and feathers and this material can end up in the scalder. Prior to slaughter, birds should be kept or held in an area that keeps them dry. Large plants may use a bird scrubber (large rotating brushes on either side of the bird) and also spray the birds with chlorinated water before putting them in the scalder.

While small processors use a single-stage, static tank, large plants use long, multiple tanks for multi-stage scalding. The tanks vary in temperature—the first is kept at a lower temperature since

Water for processing

It is important to have an adequate supply of potable water for processing. If you have well water, it needs to meet drinking water standards and should be tested. If the rate of water flow on your farm is slow, you may need to add a reservoir tank.

Table 2. Scalding

Types of Scald	Temperature	Length of time	Comments
Waterfowl (very hard)	160-180°F	30-60 seconds	Needed for waterfowl
Hard	138-148°F	30-75 seconds	Removes outer layer of skin
No Man's Land	130-138°F		Avoid: too hot to keep skin intact but too low to remove epidermis
Soft	123-130°F	90-120 seconds	Keeps skin intact

(Source: Adapted from Tanner, 1969. p. 20.)

it can take two minutes for the track to carry the birds through. In that time, they would cook at 134°F. The tanks also have a countercurrent flow of water, which produces a dirty-to-clean gradient. The scald water flows in the opposite direction from the birds, so they are continually moving to cleaner water. Overflow adds fresh water continuously.

Picking

The quality of the pick is related to the scald. If the scald water was too cool, the feathers won't loosen; if it was too hot, the skin will tear in the picker. But if it was just right, the feathers usually come out easily and can even be removed by hand. However, hand picking is time-consuming. If you are planning to process very many birds, you will need a mechanical picker. Removing the feathers by abrasion, these machines can pick a bird clean in about 30 seconds but will sometimes break the wings. A drum picker—a cylinder with rubber fingers around the exterior—defeathers one bird at a time. The operator holds the bird above the cylinder, rotating it as the cylinder spins and picks off feathers. Drum pickers come in table-top or free-standing models. A more common picker is a tub or batch picker. This is a rotating tub with rubber fingers mounted on the inside walls; it can handle two to 12 birds at a time. Small processors carry the birds to the picker. Large plants use continuous, in-line pickers that look like a tunnel with rubber fingers. Birds pass through the tunnel on shackles.

Turkeys and older laying hens are harder to defeather, and waterfowl feathers are especially hard to remove. Pinfeathers—immature feathers still in the feather shaft—can be hard to remove mechanically. "Pinning" is the removal of pinfeathers by hand. "Singeing" involves passing the bird through a flame to burn small hair-like feathers. Some on-farm processors use a propane torch to burn them off, being careful not to burn the skin. The feathers of colored birds may leave spots of pigmentation on the skin. Commercial poultry breeds have white feathers that do not leave stains. Consumers in the United States are accustomed to a carcass with a clean, unspeckled appearance.

Feathers are removed by the abrasive action of rubber fingers in this tub-style picker. Photo: NCAT

Scalding and Picking Equipment

Small scalders (one bird at a time) cost less than $200 and small pickers cost approximately $600. Companies also offer many larger models. A 12- to 16-bird scalder costs about $10,000.

Homemade or Modified Equipment

Making your own equipment is another way to lower costs, but consider the time required to build or find parts. Again, make sure the design and materials meet the specifications you require. But be forewarned that homemade equipment is not likely to meet Federal or State meat inspection requirements.

Homemade scalders: When first starting out, some small-scale producers use a large stockpot in the backyard, heated with a fire. On-farm processors have also used propane burners (from outdoor turkey fryers), water-bath pots made for canning, and hospital sterilizers (common before the advent of the autoclave). A homemade scalder can be made with a utility sink, a heating element, and a thermostat for about $50 (Beck-Chenoweth, 1996). On-farm processors also make large insulated scalders from old electric or propane water heaters. Some even have a dunker. It is especially important to use thermometers with homemade scalders to ensure a constant temperature.

For those making homemade equipment, it is very important to be aware of the danger of electrocution. Scalders and pickers are used around water, which makes improperly connected electrical parts even more dangerous. Important safeguards include using a competent electrician, following electrical code, installing ground fault circuit interrupters (GFIs), and making sure the power cord is of sufficient gauge to handle the current. Gas-powered water heaters are also used, but there is an explosion risk.

Homemade pickers: Many have converted old washing machines or plastic 55-gallon drums into pickers. On-farm processor Herrick Kimball, author of *Anyone Can Build a Tub-Style Mechanical Chicken Plucker* (Kimball, 2002), estimates that this type of picker can be built for $500—much less than the typical $2,000.

Pickers can be constructed from a plastic barrel, rubber fingers, and a small motor. Photo: NCAT

Small processors can look for used equipment from a variety of sources. There may be old poultry-processing equipment in your area from small plants of the past. Large plants in your area that are remodeling can be a source of used equipment. Large companies have graveyards with used equipment, some being turned into scrap metal. Keep in mind that while used equipment can help you cut costs, it may not meet the specifications your facility requires.

Removal of Head, Oil Glands, and Feet

After feather removal, the heads, oil glands, and feet are removed. On-farm and small processors usually cut the head off; large plants have machines that *pull* heads off so that the esophagus is also removed. Necks are typically removed and can be sold as a specialty part.

Birds preen their feathers with an oil gland located on top of the tail. It is almost 1% of the carcass, but because of its odor and taste, it is removed. Asian markets may prefer a carcass with the oil gland intact; government regulations permit it to remain under religious-kill exemptions.

The feet are removed at the knee joint. In small plants, birds are put on evisceration shackles after scalding and picking. In large plants, after the feet are removed, the birds are rehung on the shackles. When birds are first hung, it is easiest to hang them by the feet, but during rehanging, they are hung by the knee joint. This process also keeps the dirtier kill shackles separate from the cleaner evisceration shackles. In small plants with only a single line of shackles, the feet should be removed on a stainless-steel table in the scalding room and then the birds are passed into the evisceration area to be hung. One kill line feeds several evisceration lines because evisceration is relatively slow. In a small plant, nine shackles per minute is a good rate during evisceration (Plamondon, 2002a).

Evisceration

To eviscerate manually, make a circular cut around the vent and open the body to draw out the organs. Remove inedible viscera or guts (intestines, esophagus, spleen, reproductive organs). Loosen the crop so it will come out with the guts. The kidneys and lungs remain inside because they are hard to remove. Lung removers or scrapers are available that force water into the body cavity and loosen up the embedded organs, allowing them to be removed more easily.

Instead of using shackles, on-farm processors usually eviscerate on a flat surface (stainless steel for easy cleaning or a disposable plastic sheet). However, some on-farm processors use an individual shackle on a rack or stand.

On-farm processors and small plants eviscerate manually with scissors, knife, or a handheld vent-cutter gun with a circular blade, and draw out the guts by hand. Large plants use automated machines that scoop out the guts; high-speed lines eviscerate 2,000 to 8,000 birds per hour (Barbut, 2002). These automated lines are usually designed for one species, and uniformity in size is very important for proper operation.

For State and Federal inspection, the guts usually remain attached. They can be separated but must remain alongside the bird so that the inspector can see both the inside and outside of the bird as they look for disease or other problems. Inspection requires bright light, a handwashing station, and places to put suspect birds and condemned birds (Barbut, 2002). A mirror on the backside of the bird allows the inspector to examine it without touching.

If the gut is torn, microbial contamination will occur. One gram of gut content can carry a billion

bacteria (Barbut, 2002). In some countries, a spill results in the whole bird being condemned; in other countries, including the United States, washing is permitted. Small plants use spray bottles of chlorinated water to clean off fecal contents. In large plants in the United States, 2.5% of birds are condemned because of contamination. (A torn crop is also a source of contamination.) It is unknown how often the intestines tear during manual evisceration. Proper feed withdrawal before processing will help reduce tears; when the gut is full, it tears more easily. Feed should be removed from a house eight to 12 hours before processing to decrease the likelihood of contamination during evisceration.

The edible viscera or giblets (heart, liver, and gizzard) are collected. On-farm and small-plant processors peel the gizzards by hand. Many small processors simply discard the giblets. Others may collect giblets and sell them in bulk. However, inspection is required on all giblets before they can be sold. The lungs can be scraped out with a lung puller or a handheld gun used with a vacuum. Large plants automate harvesting of edible viscera and removal of lungs.

A pile-up of feathers and viscera can be a problem when processing a lot of birds. Some small plants have systems that expel the feathers from the picker to an outside container. Guts are collected in a trough and hauled away from the area in barrels. These are called "non-flow-away" systems. "Flow-away" systems in larger plants use water to remove feathers and guts continually.

Eviscerating in a small plant. Photo: NCAT

Washing the Carcass

Washing can occur at different points in the slaughter process. The most common point is before chilling, when the carcass is washed inside and out. On-farm processors usually use hoses to wash. Small and large plants use food-grade hoses and sprayers. Large plants use additives to the water, such as chlorine, to reduce bacteria.

Chilling

The carcass temperature must be lowered quickly to prevent microbial growth. The USDA requires that the temperature of the carcass be lowered to 40° F within four hours (for 4-pound broilers), six hours (4- to 8-pound), and eight hours (greater than 8 pounds or turkey) (Sams, 2001). Soaking the carcass in chilled water is the most common method of chilling poultry in the United States.

On-farm processors use large plastic tubs filled with cold water and ice for chilling. Sometimes they have two tubs, using the first to remove the initial body heat, and the second to chill the carcass. Carcasses usually stay in the water for about one hour. Small-plant processors use food-grade plastic or stainless steel bins filled with ice, in which a slush forms as the ice melts. The drainage holes in the bottom can be opened and the water drained out, leaving only ice (Elliot, 2001).

Ice is an important supply issue for on-farm and small processors. Only potable water may be used to make ice that will be used in the chilling process. A rule of thumb is one pound of ice per pound of meat. For example, in a small plant designed for 500 birds per day, 2,000 pounds of ice would be required. An ice machine with a bin capacity of 1,800 pounds costs about $7,000 and has a recovery of 900 pounds per day. In order to process on consecutive days, a second ice maker

Some on-farm processors use dairy equipment—bulk milk coolers with stainless steel tanks—for chilling carcasses. The tank never gets below 32°F, and a submersible fountain pump keeps the water circulating to ensure that chickens don't freeze to the bottom.

would need to be mounted on the bin to allow sufficient recovery (Elliot, 2001). Bagged ice is an option for chilling, but may become costly over time and hard to transport. Crushed ice is more efficient than cubed ice, which always has pockets of warmth.

Water chilling is used in most large plants. Carcasses are removed from shackles and put in large chill tanks filled with cold water. About one-half gallon of water is required per carcass for the initial tank of water (make-up water). Some chillers hold more than 300,000 gallons of water. They are either a through-flow type with paddles or rakes, or a counter-current-type with augers to move birds. The water is cooled to 32 to 39°F by a heat exchanger.

First, the carcasses are placed in a pre-chiller to cool them down gradually. The carcasses are warm (107°F) when they enter the prechiller (55 to 60°F), where they stay for 15 minutes. The carcasses are then moved to the chiller tank (32°F) and kept there for 45 minutes. Counter-currents are used so the carcass moves continually to colder, cleaner water. An overflow continually replaces water with clean water (1/2 gallon for each bird coming in). Air bubbles agitate the water to improve heat exchange.

Small processors put the carcass directly into an ice slush (32°F). Although, theoretically, cold shortening can occur, the skin pores close from the cold, reducing water uptake. Most small processors report only about 1% to 4% water uptake. In large plants, the chill water has chlorine added. Most small processors simply use city water or treated well water with negligible chlorine. Some believe that preventing a high uptake of chlorinated water can improve the quality and taste of poultry meat. Low uptake of water is an important distinction in the marketplace for on-farm and small processors.

Chill tank. Photo: NCAT

Air Chilling

Air chilling of poultry is commonly practiced in Europe, Canada, and Brazil, and was once common in the United States, where air chilling is still the norm for beef, pork, and lamb. Air chilling takes longer than water chilling, usually at least two hours.

Air chilling takes place in an insulated room or tunnel in which the temperature is kept between

Cold Shortening

Cold shortening is not a big problem with poultry since they have a fast rigor-mortis process (one to three hours after death) (Barbut, 2002). Large animals have a slower rigor process and therefore more problems with cold shortening. Theoretically, if you dunk a warm, freshly processed bird in 32°F water, the muscles will contract, resulting in tough meat; however, small processors who practice this type of chilling do not report a problem with tough meat and prefer to reduce temperature quickly.

Water Uptake

Gradual temperature reduction results in water uptake by the carcass. Most of this water is absorbed by the skin; not much goes into the meat. The cold water in the chiller seals the water gained during cooling into the carcass by closing the skin pores. USDA allows poultry to contain 8% to 12% water when sold. This regulation was developed in the past to compensate processors when excess water dripped out of packages and was lost during marketing. Nowadays, poultry meat is allowed to have 8% water in tray packs and 12% in bulk packaging, but broilers typically contain 6% water (Owens, 2001). It is obviously an advantage to poultry companies to have high moisture in their products, because it increases the weight—and the products are sold by weight. However, regulations require the moisture level to be printed on the label if the carcass was chilled using water after evisceration (USDA-FSIS, 2013).

20 and 35° F by coolers in the ceiling (Owens, 2001). Air is blown from nozzles directly into the cavity of each bird or around it. An overhead track conveys the carcasses into the room. It saves labor to keep the birds on the shackles for chilling because there is no need to handle them, but sometimes they are removed and put in baskets or on racks. To prevent an upper layer of carcasses from dripping on a lower layer, the birds are usually not stacked. Heightened humidity or a water spray prevents the carcass from drying out. *Evaporative chilling* is a type of air chill in which water is sprayed on the carcass; water absorbs heat during evaporation.

Air-chilling equipment requires more space and uses more energy than water-chilling equipment and costs more. However, water use is low. Both types of chilling are effective and the choice depends on water availability, the market, and other factors (Barbut, 2002). Air-chilled poultry is usually sold fresh. Birds that are air chilled should be soft-scalded—if they are hard-scalded, the meat may discolor.

Large plants use automated equipment to cut up, while small processors cut manually or use a saw.

There is no water uptake with air chilling. In fact, there is water loss of 2 to 4%, and the outer skin is drier (Owens, 2001). Because air chill does not promote cold shortening as much as water does, a gradual temperature reduction is not as important. Birds encounter cold air in the first stage of entering the chiller (19 to 23°F). In the second stage, the air is warmer (25 to 30°F) (McKee, 2001).

Refrigerated rooms can be assembled from insulated panels and a "coolbot" device, or used coolers can be bought from restaurant supply companies at reasonable prices. Racks for air chilling poultry that prevent the carcasses from dripping on each other can be made or purchased.

Small poultry growers in the United Kingdom use 40-foot refrigerated trucks for air-chill. The trucks must be fitted with racks, but they already have blowers. Some growers remove the wheels for a stationary set-up; others keep the trucks mobile. Other types of refrigerated vehicles can also be used. For example, refrigerated containers for ocean transport hold potential for air-chill. Some are plug-in and some rely on diesel generators.

Cut-up, Deboning, and Further Processing

On-farm processors generally sell carcasses whole—they do not offer cut-up. In small plants, about 16% to 30% of the birds need to be cut up because of bruises, broken bones in the picker, and other damage (Elliot, 2001). U.S. customers are very accustomed to the convenience of cut-up poultry and parts. In the industry, about 70% of poultry is sold as parts or further processed. Boneless, skinless breasts are a particularly popular product, and dark meat is exported overseas. Large plants use automated equipment to cut up, while small processors cut manually or use a saw.

Yields

Average yields for poultry carcasses without the feathers, blood, and viscera:

- 75% for broilers with giblets
- 65% for broilers without giblets
- 78% turkeys with giblets (due to the larger neck)

Cut-up includes removal of the wings, legs, and front halves (breast). Whole legs and leg quarters can be cut into thighs and drumsticks. Common cut-up configurations consist of eight pieces (wings, breasts, thighs, drumsticks). The wings can also be cut into drumettes. The remaining "backs" are a by-product and can be sold to make bone broth or pet food.

Small plants that debone manually place the whole bird on a cone and cut off the wings, breast, and legs. Breasts and thighs are commonly deboned in large plants with automated equipment. Meat should not be deboned for at least four hours, since rigor mortis is occurring, and deboning early would toughen the meat. (See the Aging section on page 11.)

While the slaughter areas in large plants are kept at about 65 to 80°F, the temperature is 50°F or lower in further-processing areas. The cooler and the shipping dock are 34°F or lower.

"Further processing" includes not only cut-up and deboned, but also portioned, formed, cooked, cured, smoked, and brined products. Further processing seems like another world for most small processors today, but in the future it may be an important value-adding option for them. It's important to note that further processing requires government inspection.

Portioning and sizing are important in the con-

ventional industry, because many restaurants only want to buy uniform portions of meat.

Formed products are made by reducing the particle size of the meat, adding ingredients for flavor or functionality, tumbling to increase penetration of brine, and forming with a stuffer or mold. Some products are also coated with breading and cooked. Formed products include the following:

- Whole (deli rolls and loaf); these have pieces that can still be recognized as meat.
- Comminuted (chicken nuggets, patties); the pieces of meat have been chopped and are smaller; breast meat or deboned meat and skin are used.
- Emulsified (hot dog, bologna, sausages); the pieces of meat are very small and, when mixed with fat and water, may not be recognizable as meat (Owens, 2001).

Curing and smoking are ancient ways of preserving meat that also contribute to flavor. Curing uses nitrites as a preservative. Smoking can be done without nitrites. Some small processors brine poultry. On-farm brining is usually done during chilling, but can also be done in the refrigerator. In kosher processing, the meat is salted to draw out all visible blood, because the Jewish dietary laws prohibit the eating of blood.

Aging

Tenderness is directly related to aging. Poultry meat needs to age for at least four hours before it is eaten or frozen, or it will be tough. This is because of rigor mortis—a temporary toughening—which is part of the process of muscle death, the natural biochemical process that converts the muscle to meat. Although the bird is dead, there is still energy in the muscle. The muscle cells continue metabolizing until this energy is used up, switching from aerobic metabolism to the less efficient anaerobic (without oxygen). Rigor mortis does not set in immediately after slaughter, but gradually as the muscles deplete their energy stores. "Cross bridges" form within the muscle structure, and the muscle cannot be extended. After a while, the muscle structure starts breaking down, and the muscle becomes flexible again (Barbut, 2002).

Rigor mortis is relatively brief in poultry; it is largely complete in four hours in chickens (six to eight hours in turkeys). Rigor is not *fully* complete for 24 hours, but tenderness only increases marginally after the initial four hours.

Rigor is dependent on temperature: at warmer temperatures, it occurs more quickly. However, carcass temperature must be kept low enough to prevent microbial growth.

Meat Quality Biochemistry

Meat quality is affected by any stress the bird experiences during catching, loading, transport, unloading, and immobilization before slaughter. After death, when energy metabolism switches from aerobic to anaerobic, lactic acid will accumulate in the muscle until the glycogen (stored energy) is depleted or the pH becomes too low for enzymes to work (Barbut, 2002). Animals that were stressed before slaughter will have little glycogen in the muscles. The limited production of lactic acid, and high ultimate pH that result, make the meat dark, firm, and dry (Barbut, 2002). On the other extreme, the pH can drop quickly and produce pale, soft, exudative meat.

Packaging

After the carcass is properly chilled, it is ready to be packed. On-farm processors usually don't have to refrigerate or deliver. They sell their birds fresh, immediately after slaughter, to customers who come to the farm to pick them up. They usually put the chicken in a plastic bag, close it with a twist-tie, and weigh the package. Consumers of fresh poultry must eat or freeze the birds within six days.

Small processors also package in individual bags, but they usually shrink-wrap them. Dipping the bagged birds in hot water will cause the shrink-wrap to contract, removing the air.

Another popular option for small processors is to vacuum-bag poultry. The carcass, or cut-up parts, are put into a plastic bag and go into a machine that removes any extra air and seals the package tightly. Poultry packaged via vacuum sealing are easy to label and freeze. Vacuum-bagging machines are now easy to find and can be purchased from most commercial kitchen equipment stores. The shelf life of vacuum-packed poultry is usually five to 12 days (Barbut, 2002).

In addition to individual packaging, small processors can also pack birds on ice in plastic crates that the customers return.

Tenderness is directly related to aging. Poultry meat needs to age for at least four hours before it is eaten or frozen, or it will be tough.

Dry tray packs—good for retail trade (in display cases)—may be an option for small processors. The bird is placed on a pad in a Styrofoam tray, which is wrapped with plastic film and heat-sealed. However, this type of packaging is not suitable for freezing (Elliot, 2001).

Scales that print out a label when the package is weighed are available. Producers should choose labels designed for cooler and freezer use so they won't fall off.

Freezing

On-farm processors store the carcasses for their customers in refrigerators or freezers. If storage is limited, it is best not to slaughter too many birds at a time. Loading birds that have not chilled to 40°F in your refrigerator or freezer may drive up the temperature and allow microbes to grow on the carcass. One option is to rent freezer space at another location.

Frozen poultry will stay flavorful for about six months, but after that it may become rancid.

Although U.S. consumers are accustomed to buying poultry fresh, freezing will extend the shelf life. Meat does not freeze until it gets below 28° F because of its salt content, which suppresses the freezing point. Poultry meat kept above 26° F can still be marketed as fresh (Sams, 2001).

Frozen poultry will stay flavorful for about six months, but after that it may become rancid. Don't store poultry for more than 12 months (Barbut, 2002). Freezing does not kill all the microbes; some will survive and grow after thawing.

Storage recommendations:

- At 10°F, limit storage to two months.
- At -0.4°F, limit storage to four months.
- At -11°F, limit storage to eight months.
- At -22°F, limit storage to 10 months (Barbut, 2002).

The rate of freezing affects the meat:

- Slow freezing (three to 72 hours) results in large ice crystals, which damage cells and membranes. Upon thaw, there is more drip loss.
- Fast freezing, which lowers temperature to -22°F in 30 minutes, results in small crystals (Barbut, 2002).

Methods of freezing poultry include the following:

- *Still air* is a slow method used by home freezers.
- *Blast freezing* uses cold air circulated by fans for rapid air movement. The industry uses blast freezing to form a frozen crust on a product to insulate it.
- *Liquid immersion* or spray immerses the product in a freezing liquid (Barbut, 2002).

The packaging material used for frozen meat should be strong because the meat will dehydrate and get freezer burn if exposed to cold air (Barbut, 2002). Some bags are made for cooler use and some for freezer use. The material should be moisture-proof and stretchable so that it will cling to the meat (Barbut, 2002). If meat will be frozen for a long time, it is better to vacuum-pack it. This removes the insulating air, makes a skin-tight package, and prevents water evaporation and ice formation inside. Removing the oxygen also helps reduce oxidation and rancidity (Barbut, 2002).

Bone darkening is sometimes seen in young chickens after freezing. "This shows as a dark/bloody appearance of the tips of the bones and muscle areas close to bone. Myoglobin squeezed out from the bone marrow, through the relatively porous bone structure of young chicken, during the freezing process causes this" (Barbut, 2002). It is usually seen around the leg, thigh, and wing bones, and is unappealing to consumers (Barbut, 2002).

Clean-up

On-farm processors usually clean with water hoses, using hot water and soap, followed by a water rinse and a sanitizing rinse. Small and large plants clean with pressure washers, and water is disposed of through a center drain on the floor of each room. When processing under inspection, written sanitation procedures are required.

Waste Management

Waste from processing includes offal, feathers, and blood. On-farm processors usually compost their waste. ATTRA's *Farm-Scale Composting* publication provides a list of information resources and suppliers.

Small plants usually pay rendering companies to pick up barrels of waste, often at a flat rate (the same price whether they pick up one barrel or several). Because of the high expense, some processors are considering switching to large-scale composting or to incineration.

Wastewater

A lot of water is used in processing, especially for scalding, washing carcasses, chilling, and clean up. Large plants use about eight gallons per bird. The wastewater "cannot simply be discharged into lakes and rivers because of the relatively high content of organic matter such as protein and fat and the microorganisms present" (Barbut, 2002).

On-farm processors often apply the wastewater to a garden. Small-plant processors may discharge into a municipal sewage system, but a municipality can charge high fees for treating water with a lot of organic matter. Some initial treatment at the plant will lower this cost. In fact, most large plants—and some small ones—have extensive water-treatment facilities. At large plants, water and its associated treatment as waste costs $5.00 per 1,000 gallons (Sams, 2001).

Treating wastewater starts with screening out big chunks and ends with the breakdown of dissolved organic matter by microorganisms. Treatment methods must be able to handle fluctuations in waste load, which can vary depending on what is occurring in the plant (e.g., slaughter, clean-up, or downtime). Treatment also takes into consideration the use of cleaning agents in the plant.

When planning waste management, it is critical to be aware of Federal, State, and county regulations regarding waste disposal.

Equipment and Supplies

Since birds are small, processing them doesn't require a saw, track, or other heavy-duty equipment needed for slaughtering larger animals. Equipment used by on-farm processors includes poultry crates, killing cones, scalder, thermometer, picker, stainless steel eviscerating tables or shackles, and a chill tank. Plastics, including the water hoses, should be food-grade.

Large-scale plants use costly automated equipment that is highly specialized. Industry magazines list equipment suppliers. An Internet search for poultry processing equipment will also yield suppliers and prices.

Small equipment and supplies include sanitizers, brushes, soap, paper towels, buckets, pans, brooms, mops, knives, pinning knives, lung puller, ice, scales, bags, staples, clips, plastic gloves, metal mesh gloves, hair nets, aprons, and rubber boots.

Processing Diverse Species

Because they slaughter manually, on-farm and small-plant processors can handle a wide variety of poultry. In addition to broilers, they may process large roasters and stew hens and small Cornish game hens, or other poultry species, such as turkeys, ducks, geese, quail, squab, guineafowl, and pheasant. In contrast, large plants cannot handle much diversity because their automated equipment fits one size only.

Turkeys vary widely in size, from small hens weighing 17 pounds to big toms weighing more than 40 pounds. Turkeys are also very heavy, an important consideration for manual slaughter, especially if you do not have an overhead track. Feathers and crops are harder to remove, and more ice is required. Large birds such as turkeys will take up more space in the scalder and picker, which will increase the time it takes to process an entire flock.

Because they slaughter manually, on-farm and small-plant processors can handle a wide variety of poultry.

Batch vs. Continuous Processing

Birds are processed in batches during manual processing on the farm and at small plants. Processors usually do one activity at a time. For example, all the birds may be killed, eviscerated, and chilled during the first hours of operation, and packaged during the last hours. Workers usually perform a variety of duties. On the other hand, large plants use automated, in-line equipment for continuous processing, killing birds throughout the day. Workers usually perform only one duty over and over.

Processing Rate

The rate of processing depends on the workers, the equipment, and the set-up. The workers' level of proficiency is especially important. Eviscerating is usually the most time-consuming part of manual processing, but an experienced worker can eviscerate two birds per minute. Manual cut-up and deboning requires skilled labor.

The type of equipment you buy depends on your chore cycle: whether you process a few birds often or a lot of birds infrequently. However, if the scalder is too small, it will cause a bottleneck down the line.

There are other limiting factors. If your overhead track is not motorized, the speed at which the

A typical on-farm processing setup. Photo: NCAT

plant operates will be no more than the speed of the slowest person. Is your cooler or freezer large enough to allow you to process daily? Can you empty it daily? Set-up is discussed in the next section.

Typical processing rates:

- Working alone with minimal equipment: six birds per person per hour.
- Using equipment that handles at least four birds at a time: 15 birds per person per hour.

Good layout, design, and standard operating procedures in a small plant can improve efficiency. The rates for equipment are sometimes given in terms of eviscerating speed. When evaluating processing rates, find out what the estimate includes. Is it for evisceration only, "kill-to-chill," or does it also include set-up, packing, storing, clean up, and paperwork time?

Processing Setup

Processing can be done on-farm, in a mobile processing unit, or in a processing plant.

On-Farm Setup

On-farm processors usually work outdoors, under a tree or in a shed. They use existing out-buildings or build a dedicated area, often just a concrete pad with a shed roof. These are generally not enclosed areas and are rarely screened to keep out insects. Crews needed for a typical processing day are anywhere from one to six people.

An on-farm processing setup usually includes a combination of new, used, and homemade equipment. Costs range from $100 to $500 for minimal equipment up to $4,000 for a specialty line for pastured poultry production.

Upgrading equipment is a common strategy for on-farm processors. Many start out with minimal equipment, sell it, and buy a better set of equipment. It is usually not difficult to resell used equipment.

On-farm facilities have limitations. The facility lies unused for several months of the year, because it is too cold in winter to process outdoors. Also, it is not legal in some states to sell meat from on-farm facilities. Check with your state's department of agriculture to learn where farm-processed meat can be sold.

Mobile Processing Unit (MPU) Setup

MPUs are a way for producers to work cooperatively, sharing equipment and labor, with portable equipment such as a scalder, plucker, and sink, mounted on a trailer. Many MPUs are cooperatively owned by a group of producers and coordinate the scheduling of its use. Trailers can also be enclosed to better control the climate and satisfy local regulations. Most MPUs operate under the USDA on-farm processing exemption. While these units allow more farms access to processing, potential markets can be limited due to the restrictions on where exempt meat can be sold. Most MPUs are capable of processing 50 to 500 birds per day. Special considerations needed include on-farm water and electrical hookups, a vehicle that can tow the unit, and a way to chill or freeze the poultry afterward.

Small Plant Setup

Small plants are generally specialized buildings; however, some small plants are former dairy parlors or other renovated buildings.

The USDA used to print construction guidelines for plants intending to operate under inspection. However, the USDA no longer makes prior-approval decisions. It now relies on the company, through the company's Hazard Analysis Critical Control Point (HACCP) plan, to produce a product under sanitary conditions.

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Further Resources

Most small processors recommend learning from an experienced processor. See ATTRA's *Sustainable Farming Internships and Apprenticeships* at www.attra.ncat.org for a listing of farmers seeking interns; some of the farmers process poultry.

Books on backyard poultry production describe the on-farm butchering process, especially the evisceration. Pastured Poultry Profits, by Virginia poultry producer Joel Salatin, includes photographs that show how to eviscerate.

Some Extension materials that offer how-to information for on-farm slaughter include:

- **Home Processing of Poultry**, available from the University of Minnesota Extension Service. www.extension.umn.edu/agriculture/poultry/home-processing-of-poultry
- **Home Processing of Chickens**, available from the University of Nebraska Extension Service. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1806&context=extensionhist
- **Food*A*Syst: A Food Safety Risk Management Guide for the Producer**, with good sections on processing setup and procedures, delivery and storage, and disposal of waste, is available from Kansas State Extension Service. www.bookstore.ksre.ksu.edu/pubs/FOODASYS.pdf

Information on low-volume processing on a small commercial scale is hard to find. A Ph.D. dissertation titled *Economics of Establishing a Low-Volume Poultry Processing Plant*, written by Michigan State University student Vusumuzi Dhladhla, examines four plants: with capacities of 200, 350, 500, and 1,200 birds per hour.

Books about processing in large plants offer useful information:

- *Poultry Meat Processing*, by Alan R. Sams
- *Poultry Products Technology*, by George J. Mountney and Carmen R. Parkhurst
- *Processing of Poultry*, by G.C. Mead
- *Poultry Processing Systems*, by Shai Barbut

As the number of small poultry plants grows, trade associations can help further their interests.

The American Pastured Poultry Producers Association (APPPA) is a trade association for producers of eggs and poultry meat in the United States. The organization provides a network for producers to share information with other members.

American Pastured Poultry Producers Association
P.O. Box 85, Hughesville, PA 17737-0085
888-662-7772
E-mail: Grit@apppa.org
www.apppa.org

The Niche Meat Processor Assistance Network is a network of small and specialty processors who share information and knowledge on the subject. The network operates a listserv and a website with archived information. www.nichemeatprocessing.org

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