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Wild Game: Further Processing of Wild Game Meat[1]

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Foodborne Illness Concerns

Wild game animals have many similar potential pathogens as domestic livestock (Hedman et al., 2020; Gomes-Neves et al., 2021), as well as a few additional concerns. The usual suspects include *Escherichia coli* O157:H7, *Salmonella*, *Listeria monocytogenes, Clostridium perfringens,* and *Campylobacter*, which we must also manage with commercially produced meat. However, we must also be concerned with less common agents such as *Leptospira interrogans* (cause of leptospirosis), protozoa (*Toxoplasma gondii),* parasites (*Trichinella spiralis*), and viruses (hepatitis E, rabies, and parapoxviruses) (Hedman et al., 2020) that are rare in commercial meat. The wide variety of animal species, the animal's living conditions, and the means of harvest all contribute to a difficulty in assessing the risk of foodborne illness. Temperature abuse or contamination during dressing may increase pathogens on the final product. It is important to follow good practices of temperature control (<40°F) and hygiene.

Storage of Meat

Game meat should be refrigerated for short-term storage or frozen for long-term storage. The CDC recommends freezing meat under six inches thick for 20 days at 5ºF to control the parasite *Trichinella* (CDC, 2021), although there are freeze-resistant *Trichinella* species (Sharma et al., 2020). Fortunately, trichinosis is relatively rare in Florida, with the last reported case in 2008 (Florida Department of Health, n.d.).

The choice of packaging can significantly affect shelf life and quality of the meat. Vacuum sealing is the top choice for commercial storage of meat because it reduces oxidation and microbial growth. However, there is a difference in the quality and durability of vacuum sealing equipment and bags used commercially and in the home. Commercially, chamber sealers are common and are better equipped to get a better seal due to less interference at the sealing location by liquids or the texture of the bag. Suction sealers are far more common in the home but require a textured bag to facilitate extraction of air. The suction can draw liquid up to the sealing bar, which may interfere with sealing. Additionally, most suction sealers use bags cut to size from a roll and require two seals instead of one.

Waxed butcher paper is an older but very effective material for storing meat. Tightly wrapped, it may not be quite as good as a vacuum package, but it is less expensive, far less likely to fail, and much better at preserving quality than a vacuum package with a failed seal. A combination of waxed paper and heavy-duty aluminum foil would be a reasonable substitute. Heavy-duty freezer bags may also be used, but it is important to get as much air out of the package as possible.

Dry aging refers to storing meat in a temperature- and humidity-controlled refrigerator to further tenderize meat and add flavor over time (Terjung et al., 2021). If game meat will be ground, there is very little benefit to dry aging beyond seven days. A significant downside to dry aging

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is the meat loses weight due to evaporation and a crust forms on the outside that needs to be removed. A layer of fat reduces evaporation on beef, but game meat tends to be much leaner and likely will lose more moisture. In general, meat that is already tender does not benefit from additional aging. Meat that will be ground or otherwise mechanically disrupted is made more tender, reducing any benefit of dry aging.

Thawing Frozen Meat

The process of grinding adds a lot of heat to the meat through mechanical action. This extra heat may cause fat to melt and reduce the product's quality. The higher temperature may also allow growth of microorganisms that accelerate spoilage and pathogens that could cause illness. Ideally, meat should be as cold as you can reasonably grind. Meat that is partially thawed and still "crusty" frozen works very well. The FDA Food Code defines "slacking" as "the process of moderating the temperature of a food to gradually increase from a temperature of -23°C (-10°F) to -4°C (25°F)" (FDA, 2017). Therefore, commercial facilities will use the term slacking instead of thawing. These facilities will utilize defined slack-out procedures to achieve a level of thawing that is ideal for grinding. The rate of thawing can vary significantly based on the size and shape of the meat package, so packaging meat to consistent dimensions can make thaw rate more predictable. Thawing may occur in the refrigerator or in cold water. The goal is to end up with meat that is thawed enough to manipulate, yet still partially frozen to keep it as cold as possible while it passes through the grinder. The colder the meat is during grinding, the better the final texture will be. There will also be a reduced likelihood of fat melting which may result in fat caps on formed sausages after cooking.

Sausage Making

Most game meat has much of the fat trimmed away due to an intense and undesirable flavor. However, a sausage maker may choose to add beef or pork fat up to 20%–30% to achieve a desirable consistency and flavor. Insufficient fat will result in a dry and crumbly texture. A general process may include cutting frozen meat (with added fat) into chunks small enough to fit down the throat of the grinder before a coarse grind. Seasonings and spices may be mixed in before a fine grind. The fine grind will help to incorporate the spice blend. Again, the colder you keep the meat, the better the results will be.

The extent of mixing depends on the final product. Incorporated salt will extract proteins and make the meat batter increasingly sticky. Generally, with a fresh sausage, you want to mix enough to distribute the seasonings while minimizing protein extraction. The texture of a sausage patty will become rubbery with overmixing. With cooked, smoked, or dried sausage, protein extraction is needed to bind the product together. In this case, it is beneficial to mix a portion of the meat with all the salt to increase protein extraction before incorporating the remainder of the meat. Proper mixing and protein extraction will result in meat batter that sticks to your hand if you try to form a ball.

The meat batter may then be stuffed into cellulose, plastic, or natural casings. Cooked sausages should reach an internal temperature of 160F. During the cooking process, maintain humidity in the cooking chamber. This facilitates heat transfer, allows smoke to adhere to the sausage, softens the casing, and prevents the sausage from drying out. Including a tray of water in the chamber can add humidity.

Fermented sausage may be made by introducing a lactic acid starter to the meat batter and fermenting added sugar to reduce the pH, resulting in a sour, tangy, and more shelf-stable product. This type of sausage requires the maker to have good control of temperature and humidity to facilitate acid development and prevent growth of harmful pathogens. The introduction of encapsulated citric acid can achieve a similar effect. Citric acid is encased in a heat-sensitive capsule that facilitates mixing, but prevents acid denaturation of proteins before the batter is stuffed into a casing. The capsule melts during the cooking process, releasing the acid and achieving the desired pH and flavor. **Do not** incorporate encapsulated acid before the second grind to prevent premature breaking of the capsule.

Jerky

Making jerky is one of the oldest forms of meat preservation. The premise is rather simple: remove water and add some combination of salt, acid, and spices which collectively impede the growth of both pathogenic and spoilage microorganisms. However, it is not without challenges. For instance, in 1997, there were up to 11 people in Oregon who became ill with *E. coli* O157:H7, which was attributed to homemade deer jerky (Keene, 1997).

Jerky can be made as either whole muscle or ground and formed. For whole muscle jerky, meat should be partially frozen to facilitate thin slicing. The slices can then be marinated with a combination of spices, salt (soy sauce), sugar (honey, maple syrup, etc.), and acid (vinegar, lemon juice, Worcestershire sauce, mirin, cooking wine, etc.). Ground and formed jerky follows a similar process to

sausage, but instead of being left loose or put into a casing, it is extruded through a jerky gun or rolled out and cut to size. In either case, cure may be included in the formulation, which enhances flavor, improves preservation, and provides additional control over pathogens (Harrison et al., 1998).

Drying by itself is not enough to kill pathogens. There needs to be sufficient heat and humidity to kill pathogens like *Salmonella*. *Salmonella* can desiccate (dry out) and survive at temperatures of 212°F for an hour (Gruzdev et al., 2011). However, the presence of moisture prevents this thermal adaptability. While it may seem counterintuitive, it is important to include extra humidity in the dehydrator by either filling the dehydrator to capacity, or by including a tray of water at the bottom. Anecdotally, this added humidity does not significantly slow down the drying process. The USDA recommends heating jerky to 160°F (71.1°C) and poultry to 165°F (73.9°C) (USDA, 2019). However, most home dehydrators cannot achieve that high of a temperature. The dehydrator or oven temperature needs to be significantly higher than the target temperature of the meat. Most dehydrators also take time to get to their set temperature due to their low wattage. It allows time for pathogens like *Salmonella* to dry out and adapt to the higher heat. It is recommended to precook the meat to 160°F before drying at 140°F (Harrison et al., 1998; Nummer et al., 2004). This preheating step also eliminates the need for added humidity in the dryer because the pathogens would already have been destroyed.

Curing

In the production of sausages, jerky, and other processed meats, nitrite or nitrate is commonly included to obtain a desirable color and flavor (Sebranek & Bacus, 2007). Curing also inhibits growth of a variety of pathogenic microorganisms (e.g., *Clostridium botulinum*)(Johnston et al., 1969; Sindelar et al., 2011; Majou & Christieans, 2018), particularly in combination with other commonly used antimicrobials (e.g., sodium lactate or sodium diacetate).

Ham and whole muscle products are allowed to have 200 ppm of nitrite (9CFR§424.21, 1999). Sausage is allowed 156 ppm, and bacon is allowed 120 ppm (USDA, 1995). Due to the low permissible amount of nitrite, suppliers typically provide nitrite or nitrate diluted in salt (often called Prague powder or curing salt). The diluted form reduces the likelihood of a measurement error. This is particularly helpful when using a standard kitchen scale. It is also dyed pink so the user does not mistake it for regular salt.

There is an increased desire for products that are "uncured" or "naturally" cured. These products use nitrate or nitrite from different sources such as sea salt, raw sugar, radishes, beets, or celery (Sebranek & Bacus, 2007). These alternative sources of nitrite and nitrate can be very effective as curing agents, although they tend to be less predictable than traditional curing salt.

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