

## Water Activity for Meat Snacks

Ready-To-Eat (RTE) meat snacks, such as beef jerky and pepperoni, are popular shelf-stable products for time pressed consumers desiring a healthy, tasty, and nutritious meal. Many of these RTE meat products are produced using generations old recipes to provide unique flavors. The manufacturing process of RTE meat products destroys any pathogens present and reduces the water activity below minimum growth limits for these bacteria. The reduced water activity of the RTE products makes them shelf stable at room temperature and differentiates them from perishable fresh products.

### Moisture Analysis

Traditionally, discussions on controlling water in products have focused on moisture content or the total amount of water in a system. Moisture content provides valuable information about product quality, but it is only one part of a complete moisture analysis. Water activity is the other important moisture measurement that defines the energy or ‘available’ water in a product. While both measurements are important, water activity provides the most valuable information about product safety and quality.

Water activity represents the energy status of the water in the system and is equal to the relative humidity of the air in equilibrium with a sample in a sealed chamber. It is based in thermodynamics and is defined as the vapor pressure of water ( $p$ ) over a sample divided by the vapor pressure of pure water ( $p_0$ ) at a given temperature. Though not scientifically correct, it may help to picture water activity as the amount of ‘available’ water. It is not determined by how much water is present, but is a comparison of how much the water in food resembles and behaves like pure water. Water activity values represent a scale that ranges from 0 (bone dry) to 1.0 (pure water). As water activity decreases, the water in a product decreases in energy, is less ‘available’, and behaves less and

less like pure water.

### Microbial Growth and Product Safety

The water activity concept has served microbiologists and food technologists for decades and is the most commonly used criterion for food safety and quality. Microorganisms have a limiting water activity below which they cannot grow. Water activity, not moisture content, determines the lower limit of ‘available’ water for microbial growth. Table 1 shows the growth limit for the common spoilage organisms for RTE products. These values were established under ideal conditions for microbial growth for all other growth factors such as pH and temperature. In other words, they represent the true lower water activity limit for growth under a worst case scenario.

Microorganism	Water Activity Growth Limit Value
Escherichia coli	0.95
Salmonella spp.	0.95
Listeria monocytogenes	0.92
Staphylococcus aureus	0.88

**Table 1.** Meat and poultry pathogens of concern and their water activity growth limits.

The water activity level that limits the growth of the vast majority of pathogenic bacteria is 0.90, a water activity of 0.70 is the limit for spoilage molds, and the lower limit for all microorganisms is 0.60. The 2005 U.S. Food Code, in the definition of Non-Potentially Hazardous Food, has established two interactive tables involving water activity and pH levels critical for shelf stability. Heat-treated products with a water activity level of  $<0.92$  or non-heat-treated products at  $<0.88$  aw are considered shelf stable and do not need to be refrigerated. At water activity values less than 0.87, none of the potentially hazardous pathogens listed in Table 1 can grow. The only remaining

microbial issue is molds which is controlled with preservatives or packaging. The USDA lists a more conservative water activity of  $<0.85$  as safe in their Generic HACCP Model 10 Directive for RTE jerky products.

Many RTE producers and health inspectors assume that if  $0.85$  aw is safe, then a lower water activity is better because it is 'even safer'. The target water activity range is often set at  $0.80$  or  $0.75$  aw to maximize safety. However, there is no gain in safety by drying to water activities lower than  $0.85$  aw, because the growth of all pathogenic bacteria is limited at  $0.87$  aw (Keep in mind that at  $0.85$  aw, mold spoilage can occur, but is not considered potentially hazardous). However, lower water activities can result in losses in both quality and profit. An RTE meat product that is over dried becomes tough, chewy, loses its palatability, and may be undesirable to a consumer. Additional drying also results in greater loss of water and water equals weight. In a product that is sold on a per weight basis, increased weight means increased profits. With an understanding of the critical water activity values for safety and quality, an RTE producer will optimize the water activity to make a product that will be tender and juicy, completely safe, and maximize profits.

### Food Safety and Inspection Service

The USDA Food Safety and Inspection Service (FSIS) has outlined their requirements for jerky safety in Directive 20250-3700 "Compliance Guideline for Meat and Poultry Jerky." This directive states that jerky producers should not use moisture protein ratio (MPR) as a measure of proper drying for shelf stability and safety since the water activity can vary greatly at any given MPR, due to different amounts of solutes such as sugar and salt. Instead, water activity, as measured by laboratory procedure, should be used to verify that proper drying has occurred to produce a shelf-stable product. Therefore, water activity replaces MPR as a measure of dryness for food safety, but you may still have to occasionally

measure MPR as part of the standard of identity for your shelf-stable meat product. The directive also outlines the importance of maintaining high humidity values during the lethality step to prevent pathogens from becoming heat resistant and surviving the kill step. In addition, FSIS Directive 10,240.4 "Verification Procedures for the *Listeria monocytogenes* Regulation and Microbial Sampling of Ready-to-Eat Products for the FSIS Verification Testing Program" states that *L. monocytogenes* is a hazard and that anyone producing ready-to-eat meats must develop either a Hazard Analysis and Critical Control Point (HACCP) plan or a sanitation Standard Operating Procedure (SOP) to verify that they are controlling the growth of *L. monocytogenes*. Thankfully, a jerky producer can use one HACCP plan to control all pathogenic bacteria including *L. monocytogenes*.

### Generic HACCP Model 10

In 1996, the USDA introduced HACCP programs to reduce contamination in foods by hazardous pathogens. In the HACCP program, food production companies create a plan that identifies critical control points in their processing that will prevent or eliminate contamination by hazardous pathogens. In July of 1996, FSIS published a final rule that mandates that HACCP plans be implemented to control contamination of all meat and poultry products. To assist companies in developing their HACCP plans, the FSIS has produced generic HACCP models. In February of 2005, the FSIS released a revised version of its generic HACCP model 10 for Heat Treated-Shelf Stable Meat Products. This generic model identifies water activity as the main post-lethal treatment critical control point, and as the most appropriate way to determine if the jerky product has been properly dried for shelf stability and safety. It also identifies  $0.85$  as the critical water activity value for shelf stability, and suggests that the instrument being used to measure the water activity of meat products should have an accuracy of  $\pm 0.003$ aw.

## Measurement of Water Activity

Water activity is measured by equilibrating the liquid phase water in the meat sample with the vapor phase water in the air of a closed chamber and measuring the relative humidity of the headspace. New instrument technologies have vastly improved speed, accuracy and reliability of measurements. Two different types of water activity instruments are commercially available. One uses chilled mirror dewpoint technology while the other utilizes relative humidity sensors that change electrical resistance or capacitance; each has advantages and disadvantages. The methods vary in accuracy, repeatability, speed of measurement, stability in calibration, linearity,

and convenience of use. Instruments that use resistance/capacitance sensors tend to be less expensive but also less accurate.

## Summary

The main objective in making a shelf-stable RTE meat product is to arrive at a combination of hurdles that inhibits undesirable microbial growth and water activity is one of the major barriers to prevent the growth of pathogenic bacteria. All RTE meat producers from smallest to largest need to be able to conduct water activity testing on their product to ensure it is safe. Please contact Decagon Devices for more information.