Safe Manufacture f Jerky

Workshop & Roundtable

August 15-16, 2006

FOOD SAFETY

Utah State University Extension

USU Jerky Workshop Break and Lunch Options (Tuesday)

Name _____

Refreshments

Coffee will be provided in the Conference Room in the morning. Soda will be provided during lunch and afternoon break. If you do not drink coffee or soda, you may choose an alternate in the Aggie Sales Store. There are an assortment of milks and other beverages. You may place one drink on the USU Jerky Short Course tab. Please purchase all additional beverages directly from the Aggie Sales store.

Lunch

Sandwich

Bread (1) ☐White ☐Wheat ☐ Sour Dough ☐Deli-Rye ☐Bagel

Meat (1) ☐Turkey ☐Roast Beef ☐Ham ☐Pastrami ☐Ckn Salad ☐Tuna Salad

Cheese ☐Cheddar ☐Swiss ☐Provolone

Spreads ☐Dijon Mustard ☐Honey Mustard ☐Yellow Mustard ☐Mayo ☐Butter

Veggies ☐Lettuce ☐tomato ☐onion ☐sprouts ☐grn pepper ☐pickle
☐pepperoncini ☐blk olives

Choose ONE side

☐Choc. Chip cookie ☐oatmeal raisin cookie ☐peanut butter cookie
☐Doritos ☐Fritos ☐potato chips

Soda will be provided in the Conference Room during lunch and the afternoon break. Please feel free to get a snack or additional beverage from the many choices available in the Aggie Sales store at your own expense.

USU Jerky Workshop Break and Lunch Options (Wednesday)

Name _____

Refreshments

Coffee will be provided in the Conference Room in the morning. Soda will be provided during lunch and afternoon break. If you do not drink coffee or soda, you may choose an alternate in the Aggie Sales Store. There are an assortment of milks and other beverages. You may place one drink on the USU Jerky Short Course tab. Please purchase all additional beverages directly from the Aggie Sales store.

Lunch

Sandwich

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Meat (1) ☐Turkey ☐Roast Beef ☐Ham ☐Pastrami ☐Ckn Salad ☐Tuna Salad

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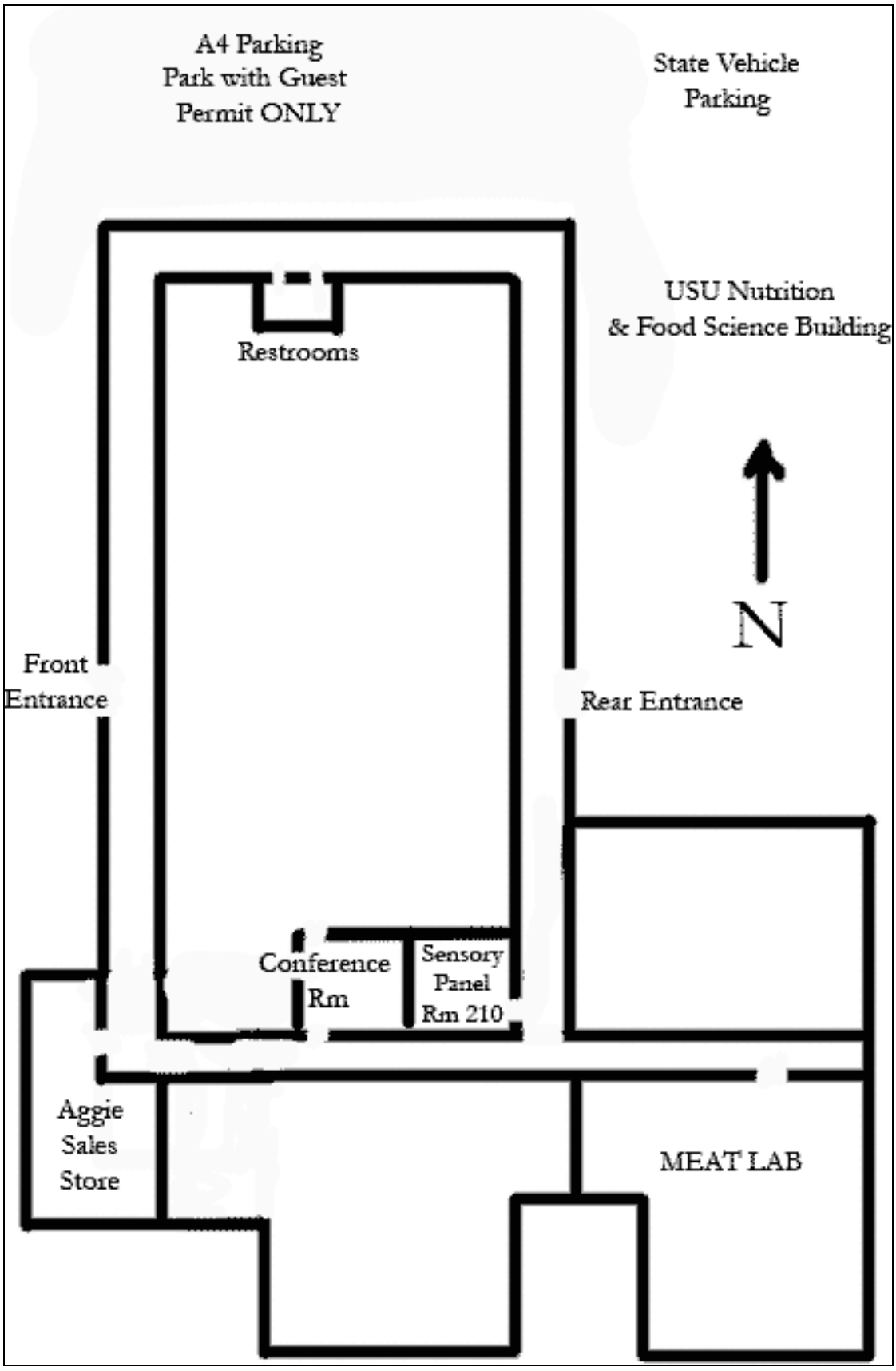
A4 Parking
Park with Guest
Permit ONLY
State Vehicle
Parking
Restrooms
USU Nutrition
& Food Science Building
N
Front
Entrance
Rear Entrance
Conference
Rm
Sensory
Panel
Rm 210
Aggie
Sales
Store
MEAT LAB

Utah State
UNIVERSITY

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August 8, 2006

Dear Participant,

It is with great pleasure that I welcome you to Utah State University and the Department of Nutrition and Food Sciences for this short course on Safe Jerky Manufacture. The outreach and extension goal of the NFS department is to disseminate and apply scientific knowledge in nutrition and food sciences to the people of Utah and the nation. Our key areas of outreach reflect the department's scientific expertise and include the focal points of this short course, food safety and meat processing.

Meat processing is my disciplinary area of expertise, and I was excited to review the programming developed for this short course by Drs. Nummer and Cornforth. I am sure that you will find the material informative, practical, and adaptable to your individual needs. I will be off-campus during the first day of your course, but I hope to share some time with you on the second day to refresh and update my learning.

I hope you have opportunity to relax and take pleasure in all that is offered on our Logan campus, community, and surrounding areas. This prospect should, without exception, include a scoop of Famous Aggie Ice Cream using the complimentary coupon contained herein.

Best regards,

C. Carpenter

Charles E. Carpenter, PhD
Professor and Head

Table of Contents

Agenda
Safe Jerky Manufacture
August 15-16, 2006

8/15 Tuesday	Pg	Topic
8:30 – 10:00 am		Registration
10:00 – 10:30 am	1	Welcome (15min-) Housekeeping (15min)
10:30 – 11:15 am	4	Why are we here? Problems in the safety of Jerky Manufacture. USDA FSIS Compliance Guidelines for Jerky Humidity & A_w Issues (20min-presentation, 25 min discussion)
11:15-noon	9	In Lab - Wet marinade Process Thermometry and Thermometer Overview (Not wet bulb)
Noon- 12:30 pm		Lunch (Facilitators will be in lab to answer questions)
12:45 – 1 pm	11	Humidity and Jerky Manufacture (15min- presentation)
1 – 2:30pm	15	In Lab Exercise: Wet bulb/ dry bulb thermometry
2:30 – 3 pm		Break and Open Discussions
3:00 – 3:15pm	16	USU Jerky Study Results (15min-presentation)
3:15- 5 pm		Humidity discussions and wrap-up (45min)

8/16 Wednesday	Pg	Topic
8 -8:30 am		Summary of Day 1 and open discussion
8:30 – 8:45 am	19	Water Activity and moisture-protein ratio (15min-presentation)
8:45 – 9:45 am	24	Lab – Water Activity Hands-On water activity (Bring sample of your own product to measure).
9:45 – 10:45 am		Humectants and Product Formulation (15m-presentation 45min discussion)
10:45- 11:30 am	25	Overview of *Listeria monocytogenes* in Jerky Manufacture (15min presentation 30m discussion)
11:30a – 12:30 pm		Lunch and Class Jerky tasting
12:30 – 1:30 pm	27	Understanding custom processes discussion
1:30 – 3pm	30	Flavor-Texture-Color Sensory Panel (15min presentation including basic panel training, 60min groups of eight go into sensory room (60 min) summation (15min) Open discussions for panelists NOT in sensory booths.
3:15 – 4 pm	33	Summation, certificate distribution and wrap-up (15min)

1. Why are we here?

1.1. There are 76 million cases of foodborne illness that lead to 325,000 hospitalizations and 5000 deaths annually. Outbreaks of foodborne illness in commercially produced jerky have occurred. An outbreak in jerky from your plant will almost certainly leave you vulnerable to lawsuits and negative media attention. The result may be the closure of your business and financial ruin. An outbreak in Utah might also affect ALL processors as consumer's lose confidence in the safety of Utah jerky.

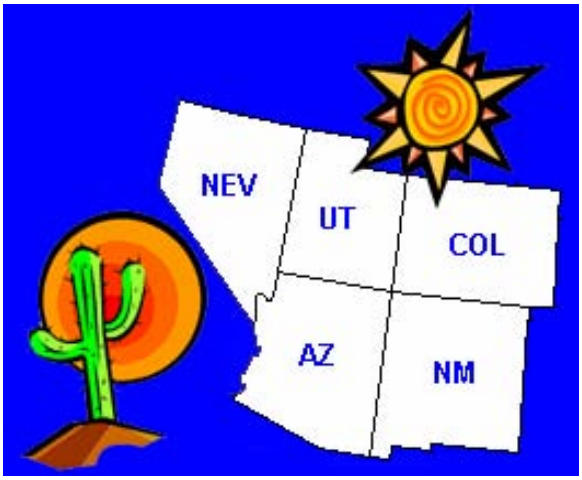
1.2. Both federal and state regulators have noticed over the years that there was a problem with foodborne illness in small and very small meat plants producing meat jerky. A number of illness outbreaks occurred including:

- 1995. New Mexico, *Salmonella* in Jerky (CDC, 1995) http://www.cfsan.fda.gov/~mow/jerky.html
- Since 1966. Eight outbreaks in New Mexico, 6 from *Salmonella* (Albanese, 2005). http://spectre.nmsu.edu/dept/docs/nmhs/Albanese.pdf
- 1995. Oregon. *Escherichia coli* O157:H7 in homemade deer jerky JAMA. 1997 Apr 16;277(15):1229-31
- 2002. California. 200 lbs recalled due to *Salmonella* http://webserver.ci.berkeley.ca.us/news/2002/04apr/042902beefjerky.html

1.3. The final straw occurred in 2003. An Albuquerque, N.M. firm recalled ~22,000 lbs of beef jerky contaminated with *Salmonella*. http://www.fsis.usda.gov/oa/recalls/prelease /pr051-2003.htm. *After this incident, in the fall of 2003 the USDA FSIS became concerned that manufacturers across the US were not adequately heat-treating meat jerky products to kill pathogenic microorganisms.*

1.4. The New Mexico *Salmonella* in Jerky Investigation

"I stood in a 180ºF oven for several minutes and waved to the director of technical services to convince him the heat treatment was not lethal. The measured wet-bulb was 85ºF, and that's about how warm it felt. In this particular instance, the jerky was dried to a crumbly state (water activity < 0.3) with 180ºF dry heat, but 20 percent of the lots still tested positive for *Salmonella*." Robert LaBudde, Ph.D.



Ultimately a dry climate, made even dryer at high altitudes, made the dry bulb temperature measurement a poor indicator of heat treatment and led to the inadequate heat lethality treatment of product. (LaBudde, 2003). http://archives.foodsafetynetwork.ca/fsnet/2003/10-2003/fsnet_october_2.htm#SALMONELLA

2. USDA FSIS Jerky Compliance Guidelines

2.1. As a result of the New Mexico *Salmonella* outbreak in 2003 the USDA FSIS found it necessary to issue a Compliance Guideline for the safe manufacture of meat and poultry jerky.

http://www.fsis.usda.gov/PDF/Compliance_Guideline_Jerky.pdf

Important Note: The USDA FSIS first issued compliance guidelines for meat and poultry jerky manufacture in the fall of 2003. Several corrections and updates later the most recent issue is dated December 2004. *Do not consult the earlier publications.*

2.2. Summary

Problem Identified	Solution
Altitude and dry climate leads to a dry cooking lethality step that is inadequate for pathogen destruction.	**Heat treatments should incorporate humidity (wet heat) before product drying occurs for adequate pathogen lethality.**
Some manufacturers use Moisture-Protein-Ratio (MPR) to determine shelf stability	**Manufacturers MUST use water activity (Aw) for shelf stability.**

2.3. Guideline or Regulation?

The publication is considered a guideline for the safe manufacture of jerky. It does not set any regulation requirements. The actual regulatory requirement is to "achieve adequate pathogen lethality" as demonstrated in an approved HACCP plan.

3. Understanding Pathogen Lethality

3.1. The safe manufacture of jerky boils down to achieving an adequate lethality for pathogen destruction and in achieving conditions that prevent their future growth (shelf life and stability).

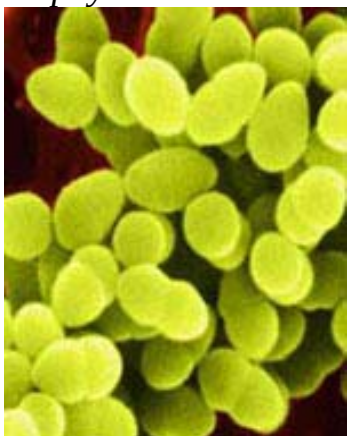
Adequate Pathogen Lethality
A lethality treatment is a process, including the application of an antimicrobial agent that eliminates, or reduces the number of, pathogenic microorganisms on or in a product to make the product safe for human consumption. 9 CFR Part 430.1.

3.2. Meat Jerky Biological Hazards (Pathogens)

Salmonella

E. coli O157:H7

Staphylococcus aureus



Listeria monocytogenes

Pathogen details are found in "Microbiology - shelf-stable dried meats" (USDA FSIS 2005) in the Literature section.

3.3. Lethality Weapons (Hurdles)

Tools to accomplish pathogen lethality in making Jerky:

- Heat
  - "Cooking" meat products to specified temperatures will destroy many microorganisms
  - *Staphylococcus aureus* produces a toxin that is NOT destroyed by heat
- Dryness – a low water activity (Aw) inhibits many pathogens
- Antimicrobials
  - Nitrite inhibits *Clostridium botulinum* (C. bot)
  - Sorbate dips used to prevent mold growth
  - Lactates and acetates added to marinades minimize Lm growth
  - Acid dips of meat can kill some surface pathogens
- Oxygen removal
  - Excluding oxygen will prevent mold from growing and encourage growth of C. bot
  - Must inhibit C. bot using nitrite and low Aw (< 0.91)

Some of these Lethality Weapons will be discussed in the coming pages.

3.4. Stress

If you think you are stressed over complying with all of the requirements to ensure the destruction of pathogens in your jerky, just think how the pathogens are feeling.

In the last few years we have learned that pathogens when stressed, such as when subjected to lethality treatments, can become more resistant to individual and multiple lethality treatments. For example, *Salmonella* subjected to acid marinades become more resistant to both acid and drying.

Basically, this means that lethality guidelines must be validated scientifically and followed carefully to ensure pathogen destruction.

4. Thermometry

4.1. Thermometers

There are several types of thermometers: bi-metal, thermistor, infrared, and thermocouple. A thermocouple type thermometer is recommended because it is instant-read, accepts different probes and is not expensive.

A typical thermocouple thermometer is shown on the next page. Thermocouple units can be purchased for one or more probe use simultaneously. A dual probe works well for jerky manufacture (wet bulb and dry bulb).

4.2. Thermometer Accuracy and Calibration

The importance of an accurate temperature reading is critical. Inaccurate temperature readings when making jerky may lead to the survival of pathogens.

FYI: An increase in only 5°F in our bodies can begin to cause brain damage.

4.3. Resolution. This is the decimal level of the readable digits, e.g. 0.1 and 0.01 are most common. ***0.1 is sufficient for meat processing.*** *The USDA FSIS allows the rounding up of any measurement from 0.5-0.9 to the next highest whole number, e.g. 154.6°F is rounded to 155°F (http://www.fsis.usda.gov/OPPDE/rdad/FSISDirectives/7370.1.pdf).*

4.4. Accuracy. The accuracy of thermometers used in HACCP facilities must be written into the HACCP plan or prerequisite program. **The recommended accuracy level is less than +/- 1.0°F.** This usually means purchasing a thermometer in the $100-200 dollar range versus less accurate models that cost less. **For Retail-Exempt facilities operating under the FDA Food Code thermometers used to measure food temperatures must have an accuracy of +/- 2°F.**

4.5. Calibration. Check, and follow, the manufacturer's recommendations on calibration and calibration frequency. Calibration frequencies should be written into the HACCP plan. They may be made daily, for each run, or at another interval. In Utah's varying altitudes it is best to test thermometers by placing the probe into an ice-water bath. The thermometer should read 32°F. Most thermocouple thermometers can be calibrated and should be adjusted per manufacturer instructions. A thermometer should be replaced when a temperature difference or drift is consistently greater than ±2°F (±0.5°C). Details on testing and calibrating thermometers can be found here (Flores, 2000 and Flores, 2000b).

4.6. Calibration Records

Record keeping is an essential component of any calibration program. To simplify record keeping, each thermometer should be marked with a permanent identification number or code. At a minimum, record: thermometer identification, date, time, intended use (hot/cold product or process), temperature reading difference from reference, and initials of person testing equipment.

4.7. Data Loggers

Data loggers are microprocessor units that both read and store data. In this case the measurement is temperature via one or two K-type probes. So, for example, both wet and dry bulb thermometer readings can be measured and logged into memory. When a run is complete the data can be transferred to a computer using several different methods. Once in the computer the data can be stored and printed. Most dual probe temperature data loggers cost from approximately 200-500 dollars.

4.8. Sources to purchase thermometers or data loggers

There are many good sources for thermometers and data loggers. The best prices are obtained by using the internet. Search for models, brand names, or just generically to find companies that offer good prices and service.

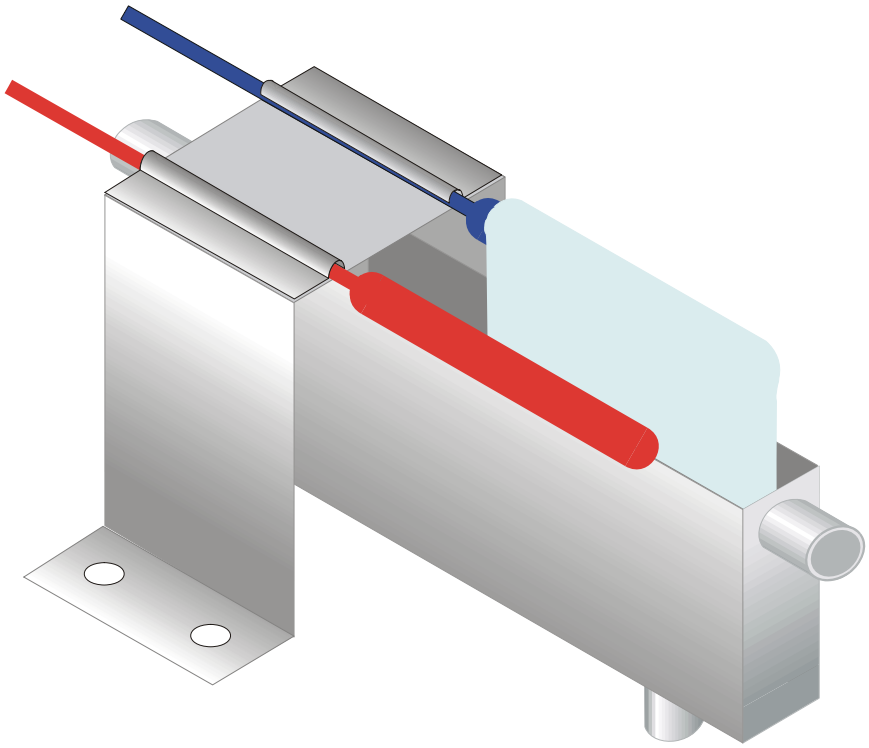
5. Humidity in Jerky Manufacture

5.1. Humidity Requirement

The recent outbreak of *Salmonella* in Jerky in New Mexico (2003) demonstrated the need for humidity during cooking for adequate pathogen lethality. Jerky that had dried before it was reached pathogen lethality temperatures resulted in the survival of *Salmonella*.

As water activity is reduced by drying food products, pathogen heat resistance increases (Goepfert, 1970).

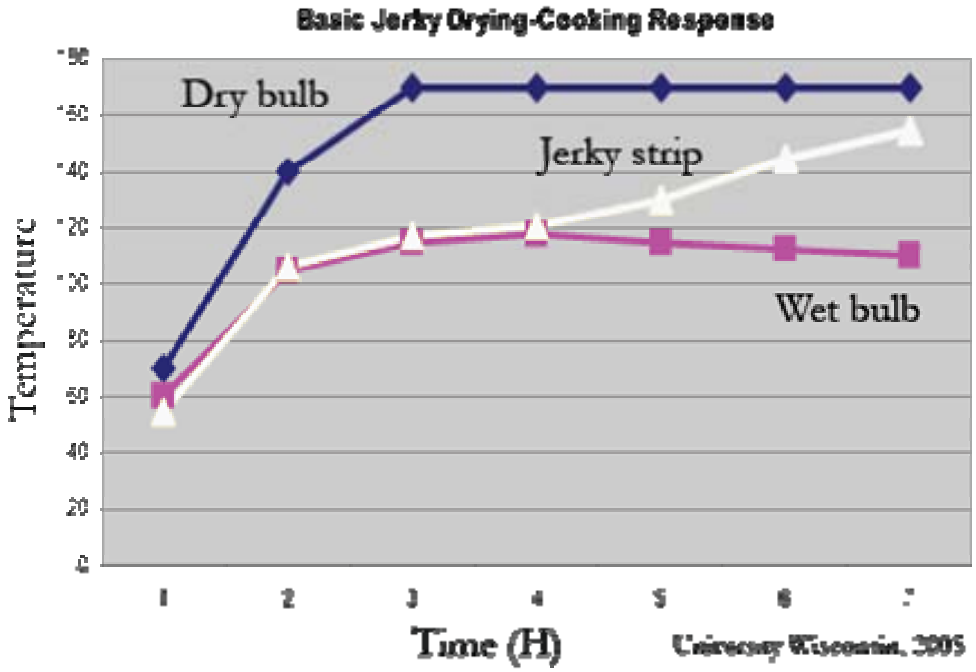
5.2. Monitoring Humidity



Bottom-left – dry bulb thermometer
Top-right – wet bulb thermometer with water reservoir and sock

A dry bulb thermometer measures the temperature of air effectively. However, dry bulb temperatures do not accurately measure the temperature of foods such as jerky. When moisture evaporates from meat it cools the meat resulting in a temperature lower than the air temperature. **This is called evaporative cooling.** Once the moisture in the meat has been evaporated, then the dry bulb and wet bulb temperatures will get closer.

5.3. Basic jerky drying-cooking response



This is a temperature graph of a typical jerky drying process where a closed oven was set to a dry bulb temperature of 170ºF.

- The meat reached ~120ºF in 2 hours and maintained that temperature for ~1 hour -- *wet-bulb and product temperature the same*.
- Once drying occurred, the jerky temperature began to rise.
- Based on the wet/dry bulb differences this oven never got close to having 90% humidity.

5.4. Options to create and preserve humidity

As seen in the previous graph a typical 170ºF dry heat jerky process lacks humidity. The USDA FSIS Jerky Manufacture Compliance Guideline mentions several options to create and preserve humidity.

(Student Activity: List positives and negatives)

Seal oven	**Place shallow pan of water in oven**
Inject water into hot oven (e.g. using existing atomizer)	**Inject steam**

All of these options will add some humidity to a jerky oven; however, actual measurements of humidity must be made to validate their effects.

5.5. Using USDA FSIS time-temperature tables to validate lethality

The USDA FSIS Jerky Compliance Guideline clarified the requirement for humidity when using Appendix A or the time-temperature tables for cooking ready-to-eat poultry products. It is important to note that the temperatures listed in the time-temperature tables are for WET BULB thermometer readings. To use these time-temperature tables for jerky pathogen lethality the humidity must be maintained at 90% or greater. Basically, the wet bulb and dry bulb temperature difference cannot be greater than 4ºF. This is VERY difficult to achieve.

5.6. Submersion cooking to achieve adequate pathogen lethality

Heat jerky covered in liquid (100% humidity)

- Heat beef strips to internal temperature of 160ºF in either water or marinade (Harrison and Harrison, 1996).
- Heat beef strips in water or marinade to an internal temperature-time per Appendix A.
- Heat poultry jerky to internal temperature of 160ºF in either water or marinade; or, follow Poultry time-temperature tables (reference).
- **USU Wet Marinade process (described later in this text).**

5.7. Additional processing alternatives

Additional alternatives are available. Some custom processes have been published. These may be used for validating a safe pathogen lethality providing they are using the same meat species, same type of jerky (sliced or comminuted), and same process. The remaining alternative is to validate your own process. More details on this subject are found later in this text and in the literature section (and on the CD Rom).

Humidity in Jerky Manufacture (Exercise 1.)

1. Create your own wet bulb probe for use with a K-thermocouple type thermometer. (Instructions attached)

2. Measuring wet and dry bulb temperatures

Oven	Treatment	Dry Bulb reading	Wet Bulb Reading
1	Sealed Oven		
2	Pan of water in bottom / sealed oven		
3	Steam injection using household steam machine		
4	Class Jerky project oven		

3. Calculate %RH of Ovens 1-4. Can you draw some conclusions from this data?

Oven	%RH	Conclusions
1		
2		
3		
4		

6. USU Jerky Wet Marinade Process (Summary)

6.1. Traditional Process may not be safe

With the new jerky manufacturing guidelines some traditional processes used by processors may no longer be considered safe. Manufacturers must either validate their traditional process to ensure pathogen destruction or modify it using research tested methods. One such method to ensure pathogen destruction is to pasteurize meat strips in a wet marinade or solution.

6.2. The U.S.U. Jerky Study

In this USU study two new treatments were analyzed that may be used by jerky manufacturers to produce safe meat jerky (marked*). Two treatments are not recommended without further research (marked **X**-).

A1. **X**-Using Appendix A lethality guidelines: 130ºF wet bulb for 121 minutes with 90% relative humidity
A2. 130ºF wet bulb for 60 minutes (University Wisconsin validated method)
B. **X**-Cook in a marinade pan in the oven 130ºF product temperature for 121 minutes
C. * Cook in a marinade pan in the oven 140ºF product temperature for 12 minutes
D. * Cook in marinade outside of oven 158ºF product temperature for 1 second

Both ground and whole beef samples were used. A standard marinade containing spice, sodium nitrite, and salt was used. After lethality treatment options above, all jerky was dried at 125ºF dry bulb for approximately 3 hours (for a targeted $Aw \leq 0.85$).

6.3. Treatments NOT recommended

For treatment A1 we could not get our oven even close to the 90% relative humidity level with the oven sealed and a pan of water placed inside. Therefore, a validated treatment from the University of Wisconsin was used (A2) as the control. Treatment B produced a ground meat jerky that cultured Enterobacteriaceae and was removed from further consideration.

6.4. Sensory Analysis of Experimental Jerky

The wet marinade pasteurization processed jerky (treatments C and D) were compared to the control (University WI method; A2) for cohesiveness, spice intensity, toughness, surface darkness, and interior color. In initial trials it was evident that the wet marinating process produced very light and unacceptable color and flavor. Therefore, the spice levels for treatments C and D were increased 1.5 times that of the control (treatment A2).

- All ground meat jerky samples were equally cohesive
- Even with a 1.5X level of spice the control (A2) had more spice intensity than both C and D.
- Treatment D produced the toughest jerky, followed by the control (A2) and then C.
- Treatment C produced the darkest color, followed by D, and then the control A2.
- Lastly, the control (A2) had the best interior color, followed by D and then C.

6.5. Conclusions

- The wet marinade pasteurization method made acceptable jerky to sensory panels.
- Both comminuted and whole muscle beef jerky can be made using the wet marinade pasteurization method.
- The wet marinade pasteurization method will require an increase in the amount of spice used versus dry spice (traditional) methods.
- Wet marinade pasteurization (cooking) can be done inside the jerky oven (in a specially made pan) or outside in a cook pot.

6.5. Water Activity Instrument Comparison

Another part of the study compared the three water activity instruments detailed in the following Section. It was found that all three measured water activity with the same accuracy.

7. Water Activity and Moisture-Protein Ratio

7.1. MPR

Jerky must have an MPR of 0.75:1 to meet the standard of identity labeling requirements for jerky. Standard of identity does not relate to safe processing. The USDA FSIS has issued a clarification that processors should NOT use MPR to determine the dryness and hence the safety of their jerky. Shelf stable product with MPR greater than 0.75:1 can be labeled "kippered". For complete product identities consult the Food Standards and Labeling Policy Book (USDA, 2005).

7.2. Water Activity vs. moisture content

Moisture content is a measure of "all" of the water in a food system. Water activity (Aw) is a measure of the "free" water available for use by microorganisms. Some moisture or water can be chemically tied up, or "bound" to molecules such as protein, sugar and salt. Bound water is NOT available for microorganisms to use. Thus, the measure of Aw is a *true* measurement of the water available for microbial growth.

Moisture = Chemically "bound" water + "Free" water (Aw)

Another way to understand water activity is that it is the relative humidity of the air surrounding a sample in a closed container related to that of pure water. [Aw = RH/100]. Thus water activity is always expressed on a scale between 0.0 – 1.0.

7.3. Water Activity and pathogens

	Minimum A_w for growth
Escherichia coli	**0.95**
Salmonella spp	**0.95**
Listeria monocytogenes	**0.92**
Clostridium botulinum	**0.91**
Staphylococcus aureus	**0.86**

Jerky with a Water Activity of 0.85 or below is considered shelf stable and does not require refrigeration. The USDS FSIS suggests that processors use a lower maximum Aw of 0.80 in the Model Jerky HACCP plan. The origin of the 0.80 FSIS recommendation is cloudy, and 0.85 should be sufficient. Keep in mind that we learned earlier that rapid drying of jerky prior to reaching lethality temperatures can produce a "dry" jerky where *Salmonella* can survive.

7.4. Water Activity and mold

At water activity levels greater than 0.70 molds may grow. Therefore, molds must be controlled using another hurdle in all products where the Aw exceeds 0.70. Some suggestions are:

- Vacuum package
- MAP package (no oxygen in mixture)
- Oxygen scavenger
- Potassium sorbate spray (3 oz/ gallon) applied post-drying

A tip from the USU Meat Lab: Use caution when vacuum packaging very dry jerky. The edges of the meat can actually puncture some packaging.

7.5. Water Activity and Product Formulation

Humectants – are compounds such as sugar and salt that "bind" water and effectively reduce water activity (Aw). A processor could add more sugar and/or salt to a marinade to reduce water activity (Aw) in small amounts. Drying is the only method that will reduce the water activity significantly.

7.6. Water activity meters

Decagon (http://www.decagon.com/)
Decagon, Inc. produces water activity meters in two lines: Aqualab and Pawkit. Both of these meters take less than 5 min. to determine Aw. The Aqualab Lite is recommended for jerky processors with a accuracy level of ± 0.003 Aw. It uses a dielectric humidity sensor. The approximate cost is $ 3300. The Pawkit is a less accurate model reading ± 0.02 Aw, but costs less at $1500.

Rotronic (http://www.rotronic-usa.com/)

Rotronic, Inc. offers three series of water activity meters: hygropalm Aw, hygrolab 2, and hygrolab 3. All of these meters determine Aw in as little as 5 minutes. The Hygropalm Aw is recommended for smaller jerky processors with an accuracy level of 0.015 Aw. It uses an integrated circuit humidity sensor. The approximate cost is $ 2300.

Aw-Wert-Messer (http://www.lufft.de/index.html)

Lufft, GmBH (Germany) available at Abbeon-Cal http://www.abbeon.com/ (800-922-0977) offers a single unit that measures water activity using a humidity sensitive fiber. This method requires 1-3 hours per sample and is operated best at 20ºC (68ºF). Sample temperatures different from 68ºF will affect the Aw reading and an adjustment is required. The approximate cost is $ 1300. The accuracy level is 0.02 Aw.

Meters mentioned above where used in USU research and are just some of those available. No endorsement of one meter or manufacturer over another is implied.

HACCP Plan Tip: If Aw is used as a Critical Control Point in your HACCP plan you must account for the error (accuracy level) in your meter. E.g. if you have an Aw critical limit in your HACCP plan of 0.90, then the reading of the sample must be 0.88 or below to factor in the margin of error.

7.7. Water activity sample preparation

At least three samples per batch taken from different parts of the jerky oven should be used. If any sample exceeds a critical limit, corrective action is required.

In-house measurement

- *Cut or chop jerky meat pieces enough to fit into sample cup without overfilling. No more than 5-10 grams are needed for any model tested by USU. *It is best to cut or chop samples to avoid errors due to any non-uniformity between surface and interior. (e.g. case hardening)

- Samples should never be allowed to touch the sensor in any water activity meter.

Third party measurement

- Approximate 25 g samples are best to send to third party labs.

- Place samples in moisture-vapor proof bags to prevent changes in moisture.

- Hold all product until analyses are completed.

7.8. Water activity meter calibration

Water activity meters are calibrated using salt solutions created at standardized water activity levels. Each manufacturer provides standard salt solutions and instructions.

7.9. Laboratory resources for Water Activity Analysis

- Miller Labs, Ogden UT 801-627-2202
- Warren Analytical Labs, Greely, CO 970-475-0263
- Microbac Labs, Boulder, CO 303-581-0195

Contact individual labs for pricing and details. Labs are mentioned for the readers' convenience and are not meant as an endorsement.

Water Activity (Exercise 2.)

This exercise is meant to give you hands-on experience working with the various types of water activity meters. Several samples of jerky are available to test and participants have been asked to bring a sample of their own jerky to test. Follow the instructions given for each meter and record data below.

Sample Number	Decagon Lite	Rotronic Hygropalm Aw	Aw Wert Messer
USU Jerky Sample No.1.			
USU Jerky Sample No.2.			
USU Jerky Sample No.3.			
USU Jerky Sample No.4.			
Personal sample No. 1.			
Personal sample No. 2.			

8. Addressing *Listeria monocytogenes*

8.1. Lm concerns

Listeria monocytogenes (Lm) is especially pathogenic to high-risk populations, including pregnant women, newborns, elderly, and people with weakened immune systems. Numerous outbreaks in food have occurred. In the meat processing industry Lm has been found on raw meats, equipment surfaces, floors, walls, drains, overhead structures, and most importantly on ready-to-eat product. This is further complicated by the fact that Lm can survive and grow in refrigerated, packaged, ready-to-eat products and resists high salt levels, nitrite, and acid. In addition, it can grow in vacuum packaged products. In response to this biological hazard the USDA FSIS created new regulations for meat processors producing ready-to-eat product.

8.2. *Listeria monocytogenes* Verification (9 CFR 430)

On June 6, 2003, FSIS published a regulation that requires establishments that produce certain RTE products to prevent product adulteration by *Listeria monocytogenes*. Establishments have three alternatives from which to choose in order to meet the requirements of this regulation. Meat jerky exposed to the environment after cooking (lethality treatment) is required to comply and processors must choose one of the 3 alternatives.

- Alternative 1 – post-lethality treatment AND an antimicrobial treatment that reduces or eliminates Lm
- Alternative 2 - post-lethality OR an antimicrobial treatment that reduces or eliminates Lm
- Alternative 3 - Sanitation Program

8.3. Meeting Lm requirements in Jerky Manufacture

If your operation is operating under a HACCP plan, then it almost certainly has a hazard and CCP indicating that post-lethality exposure to the environment may cause contamination by Lm.

Research from the University of Wisconsin in documented publications has indicated that:

- An Aw of 0.88 or less is an effective antimicrobial treatment for Lm (note that 0.85 or less is required for inhibition of *S. aureus*).
- A one-week storage period of packaged jerky at room temperature (70ºF) also serves as an efficient lethality treatment.
- Together, these first two points may allow processors to operate under Alternative 1.
- More than one-week of storage (70ºF) increases the destruction of Lm in dried and packaged meat jerky. (Note: this treatment is particularly easy to achieve in all facility types, including retail-exempt and the smallest of processors).

HACCP validation publication: Page 9 of http://www.fsis.usda.gov/oppde/rdad/FRPubs/97-013F/LM_Rule_Compliance_Guidelines_May_2006.pdf and http://www.fsis.usda.gov/PDF/New_Technology_C-27-3_RTE_Meat_Products_FY2003.pdf

There are other suggested Aw parameters to prevent Lm growth mentioned in this article (http://www.decagon.com/info/awnews04.pdf); however, the experimental data are not cited.

Research from Colorado State University has shown that several pre-treatments of meat slices have an antimicrobial effect, e.g.

- Dip meat strips in 5% acetic acid for 10 minutes prior to heat treatment and drying. (J Food Prot. 2006 Jan ;69:62-70).

Other Lm processes to explore

- Sodium diacetate to 0.25 %
- Sodium lactate or potassium lactate to 4.8 %

9. Custom Jerky Processes

9.1. Developing Custom Processes

Establishments, or their processing authorities, may develop customized processes that achieve an appropriate reduction of pathogens throughout the product. Customized processes should be based on a scientific rationale that is supported by experimental data. They may be developed by using information:

- obtained from scientific literature
- from unpublished studies that are scientifically valid
- comparing the methods used by the establishment with established procedures (e.g. Appendix A).

Alternative or custom processes must be validated (9 CFR 417.4). At a minimum, a study should identify the hazards (e.g. *Salmonella*, *Staphylococcus aureus*, *E. coli* O157:H7, and *Listeria monocytogenes*). Validation studies must then demonstrate that the custom process can achieve the required $\log^{10}$ reduction of the pathogens. Processing conditions (e.g., time, temperature, and humidity), critical ingredients (e.g., salt, sugar, and cure), and critical product characteristics (e.g., pH, water activity, and fat content) must be recorded.

It is strongly recommended that an establishment work with USDA or state inspection officials to make sure that the validation study will be accepted in its entirety and achieve the goal of complying with USDA regulations.

9.2. Published Custom processes

Due to the cost of validating custom processes, it may be advantageous to use a validated and published custom process. Several researchers at Utah State University, University of Montana, Kansas University and University of Wisconsin have published custom process validations. Some of those studies have been included on the resource CD-rom with this textbook.

10. Retail and Custom Exempt Processing

10.1. Retail-Exempt Operations

In some states retail operations that process jerky are regulated under the U.S. FDA Food Code or state regulations based on the Food Code. Smoking, curing, and reduced oxygen packaging requirements are found in Annex 6 of the 2005 Food Code (http://www.cfsan.fda.gov/~acrobat/fc05-a6.pdf). The Food Code specifies that a Regulatory Authority may ask for, and approve, a HACCP plan for any food manufactured in a retail setting. Pages 558 – 562 in Annex 6 has some specific recommendations for safe curing, smoking, and cooking meat products under the Food Code.

10.2. Custom-Exempt Operations (Discussion)

Notes:

U.S.U. Tip: Retail and Custom Exempt processors should consider holding product at room temperature for one week or more as an added hurdle against pathogen growth. The University of Wisconsin has demonstrated that some pathogens are reduced several logs after one week of storage at room temperature. This would be a very inexpensive hurdle to apply.

10.3. Resources for Retail- and Custom- Exempt Operations

Several resources that may help the retail-exempt or custom-exempt processor are included in the CD-rom that accompanies this textbook.

- Guidance for Processing beef jerky in Retail Operations (AFDO)
- Association of Food and Drug Officials Retail Meat and Poultry Processing Guidelines
- Generic HACCP Model for Heat Treated, Shelf Stable Meat and Poultry (USDA FSIS)
- Thermometer Calibration Guide (Kansas State Univ.)
- Effects of Preparation Methods on the Microbiological Safety of Home-Dried Meat Jerky (Univ. Georgia)
- Sample Jerky HACCP plan in editable MS-Word files (University Wisconsin)
- Model SSOPs (University Wisconisn)
- 2005 Food Code Annex 6 (U.S. FDA)

11. Sensory Analysis of Jerky (Exercise 3.)

11.1. Introduction

Sensory evaluation is important in the development of new food products, and as part of on-going food quality assurance. It can be an informal process conducted by food quality assurance staff, but at some point is may be valuable to conduct more in-depth, statistically valid studies. The type of panel to conduct will depend upon the type of information needed.

11.2. Consumer Hedonic Panels

Consumer hedonic panels are done to determine how well consumers like the product. Because consumers vary so greatly in their taste preferences, consumer panels should consist of 50-100 panelists. Panelists would be asked to rate the sample attribute (flavor, appearance, texture) on a 1-9 scale, where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely. Comparisons can be made between your company product and another product in the market, or between different formulations of your own product.

11.3. Trained Panel

Another common type of panel is the trained panel. Typically, a larger group of 10-15 panelists are invited to a training session, where they taste the product and discuss the product attributes. The goal of a trained panel is to obtain a small group of people (5-10 members) who are very consistent and in good agreement regarding the intensity of product attributes (toughness, cohesiveness, color, spiciness). In effect, the panel functions as an "instrument" for measurement of product characteristics. At the training session, panelists who are most consistent and accurate in identification of product characteristics after the discussion are those who will be asked to participate in future trained panel sessions.

Once the trained panelists have been selected, they are asked to rate the intensity of sample attributes on a 1-5 scale, where 1 = no detectable intensity, and 5 = extremely high intensity for toughness, saltiness, etc.

Panelists can also comment on their perceptions of the product (too salty, etc), but cannot be asked how well they like the product. This is a hedonic question, and the trained panel size is too small to obtain accurate values of consumer likes and dislikes.

11.4. Jerky Trained Panel Training Session

1. Invite 10 – 20 potential panelists to the training session. Potential panelists should preferably be consumers of jerky or shelf stable meat snacks.

2. In a group setting (around a table), explain what jerky attributes are to be measured. In this project, we were interested in jerky spiciness (hotness), cohesiveness, toughness, surface darkness, and cured color intensity (internal redness).

3. For each attribute, serve samples that are high and low in the attribute. For these "anchor points", have everyone rate the sample on the 1-5 scale. Then discuss the results. The objective is to have everyone agree upon what extremely spicy samples taste like, compared to samples with no or low spicy flavor. Another benefit of the discussion is that panelists may discover other important sample attributes, such as rancidity, or "beefy" flavors, that may be important to add to the future ballots.

4. At the end of the training session, or in a second training session, serve 3-4 samples to panelists in separate booths, without discussion. One sample should be served twice, with different codes, to check for panelist consistency. Select the most accurate and consistent panelists to participate in future trained panels.

Reference: IFT, 1981. Sensory evaluation guide for testing food and beverage products. Food Technol. November issue, pages 50-59.

11.5. Example Jerky Anchor Point Samples (Mention of a brand does not constitute an endorsement of that product).

Numbers in parentheses refers to the intensity level of the training sample.

- **Extremely Hot or spicy** - (5) Inferno brand Hickory Smoked Beef Jerky (Smoky Ridge, Inc., Lewiston, UT)

- **Slightly Spicy** (2) - USU mild beef jerky (USU Meat Laboratory, Logan, UT).

- **Extremely Cohesive** (5) - Oberto Kippered Beef Steak (Oberto Sausage Co., Seattle, WA).

- **Not Cohesive (mealy)** (1) – Vienna sausage (any brand).

- **Very Tough** (4) – Oberto Peppered Beef Jerky

- **Not Tough** (1) – Oberto Pepperoni Flavored Sausage Stick

- **Very Dark Surface** (4) – Oberto Peppered Beef Jerky

- **Slightly Dark Surface** (2) – Oberto Kippered Beef Steak

- **Extremely Red (cured) internal Color** (5) – Oberto Pepperoni Flavored Sausage Stick

- **Slightly Red Internal Color** (2) – Oberto Peppered Beef Jerky

11.6. Sample Sensory Ballot for Jerky Project

Name: Date:

Sample No.	Spice Flavor Intensity	Cohesiveness	Toughness	Surface Darkness	Cured Color Intensity (Redness)	Comments
853						
190						
627						
324						

Where 1 = not intense (none)
2 = slightly intense
3 = moderately intense
4 = very intense
5 = extremely intense

Please note. Use only whole numbers for rating products. Do not use zero.

12. Summary and Take-Home Message

1. A foodborne illness in jerky could devastate the economic viability of the industry both in Utah and regionally.

2. Manufacturing safe jerky is not difficult. The USDA FSIS published compliance guidelines to help in the safe manufacture of jerky. Two main food safety guidelines were:
   - Humidity is required during the cooking step to achieve adequate pathogen lethality, and
   - Water activity (Aw) is the only acceptable method to determine dryness for safe shelf stability

3. Humidity measurements can be made using a wet bulb and dry bulb thermometer. A wet bulb thermometer can be easily made in-house. Thermometers should be calibrated often. Calibrations and temperature measurements should be recorded.

4. Achieving adequate humidity during the cooking step can be accomplished by sealing the oven, adding a pan of water to the oven, injecting water via an atomizer, or injecting steam. Regardless of which method is chosen the relative humidity must be monitored to assure humidity is controlled.

5. One effective method to ensure wet cooking is to cook jerky in water or marinade according to Appendix A. The USU study found that jerky made with this process was acceptable to consumers.

6. Water activity is the only acceptable measurement to determine the shelf stability of jerky. There are several meters available at approximately $1500 - $3000. A moisture-protein ratio is still required for labeling purposes.

7. Listeria monocytogenes is a concern in all ready-to-eat jerky products. Research from the University of Wisconsin has suggested that producing jerky with an Aw <0.85 and storing jerky for one week at room temperature can combine to inhibit Lm growth to allow processors to operate under Alternative 1.

8. It is recommended that Retail-exempt and Custom Exempt processors have a HACCP plan. Regulatory authorities may or may not require it. Templates for HACCP lans are included in this textbook.

9. Simple Sensory Analyses can help processors develop consumer acceptable jerky, while maintaining food safety processes.

13. Literature

The following literature sources are available on the accompanied CD Rom or via the internet where indicated. Please note that not all publications are cited in the text.

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