Cornell University
Cooperative Extension
Seneca County

Meat Preservation Workshop

Seneca County CCE

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Food Safety – why we need to follow tested directions

Foods are biological materials and are therefore subject to many changes during handling, processing, and storage. There are four major causes of food spoilage:

1. Microbial spoilage:
    a) Bacteria
    b) Molds
    c) Yeasts
2. Chemical spoilage
3. Physical spoilage
4. Vermin or insect infestation

1. Microbial spoilage:

Microorganisms are tiny living organisms. Bacteria, yeasts, and molds are microbes that are important in the food industry. Desirable, controlled growth of selected microorganisms provides us with delightful, flavorful products such as cheeses, yogurts, sauerkraut, bread, and wines.

The most common cause of food spoilage is the unwanted, undesirable growth of yeasts, molds, and bacteria. When we use the term “growth” we mean an increase in numbers or population. Furthermore, improperly handled or stored food can carry and transmit diseases as a result of growth of organisms such as *Staphylococcus aureus*, *Salmonella*, and *Clostridium botulinum*.

Thousands of species of microorganisms exist in nature. Microorganisms only become visible when growing in masses containing millions of cells. For example, more than 250,000 of them will fit onto the head of a pin! Because microorganisms are so widely distributed in the soil, water, and air, it is normal to find many types and species on the surfaces of fresh foods. Their vegetative cells are easily killed by heating food to a boiling water temperature. However, the vegetative cells of some bacteria are capable of forming spores that resist death during heating. Spores are a form of the organism that survives in a resting (or hibernating) state. When a favorable environment occurs, the spores will germinate and produce vegetative cells. The growth of vegetative cells on food is influenced by temperature, the availability of moisture, nutrients, oxygen, acidity, and growth inhibitors.

a. Bacteria:

Bacteria come in many shapes including rods, balls, or spirals. They grow and increase in number by the splitting of a single cell. Some cause diseases and are known as pathogens. Foodborne means the pathogens can be transmitted by food. Many non-pathogenic bacteria cause spoilage when they grow on food.

Time Span Effect on Bacterial Growth	
Time in Hours	**Number of Bacteria**
0	1
0:10	2
0:20	4
0:30	8
0:40	16
0:50	32
1:00	64
1:30	512
2:00	4,096
2:30	32,768
3:00	262,144
3:30	2,097,152

This chart represents a generalization of how one bacterium has multiplied to 2,097,152 by the end of 3.5 hours at an appropriate temperature, under suitable conditions. Different types of bacteria will have different growth rates depending on the conditions under which they multiply.

b. Molds:

Molds grow on most foods and require air and water, although they need less water than bacteria. In appearance, their masses of growth usually are fuzzy and can be nearly any color. Some molds produce toxins that are carcinogenic (cancer causing). These molds commonly grow on fruits, fruit products, grains, grain products, and some cheeses.

c. Yeasts:

Yeasts can grow with or without air and require more water than molds. Their masses in or on food appear as slime, scum, or murkiness. Yeast fermentation in food is recognized by gas bubbles, froth, or foam, which result from the fermentation activity and the production of carbon dioxide gas. Depending on the specific growth conditions, yeasts convert sugars to ethanol and then bacteria convert the ethanol to vinegar, alcohol (e.g., beer and wines), or carbon dioxide (e.g., raised bread) during fermentation.

2. Chemical spoilage:

Chemical spoilage is usually the result of enzymatic reactions. Enzymes are organic compounds produced by all living things. The function of enzymes is to assist and speed up metabolic reactions, such as color and flavor changes in ripening fruits and vegetables. These enzymes continue to function even after foods have been harvested. Deterioration can result unless these enzymes are controlled or destroyed by food processing techniques.

3. Physical spoilage:

Dropping, cutting or other physical damage to foods can cause bruising, wilting, and water loss. Loss of moisture changes food quality. Besides detracting from the food's appearance and appeal, this kind of damage can also promote the growth of undesirable spoilage microorganisms and increase enzymatic activity.

4. Vermin:

A great deal of food is spoiled each year by rats, insects, and other pantry pests. To avoid stored food pests, use good sanitation. Clean up spilled foods. Store dry foods in covered containers.

Through these four means, improperly preserved foods can lose their aesthetic appeal, nutritional value and worse, may become hazardous. By investigating the various causes of spoilage and the effects of various food handling, preparation, packaging, and storage techniques on food quality, we can learn to distinguish between safe and hazardous preservation methods.

Factors that influence preservation of food

There are four primary factors that influence the type, number, and growth of microorganisms in food:

1. Temperature
2. Water
3. Acidity
4. Oxygen

By controlling one or a combination of these factors we can safely preserve food at home.

1. Temperature

Temperature control is the most commonly used method of home food preservation. Methods included in this category are:

1. Refrigeration
2. Freezing
3. Blanching
4. Pressure Canning
5. Boiling Water Bath Canning

Microorganisms that cause food spoilage are sensitive to changes in environmental temperature. High temperatures (greater than 140˚ F) inhibit their growth. Microorganisms multiply fastest between 40˚ F and 140˚ F, thus, in food handling; this temperature range is referred to as the "danger zone".

To prevent growth of microorganisms in food and subsequent microbial spoilage, food must be kept out of the temperature range that allows growth. Refrigeration slows down microbial spoilage. Freezing and storage at 0˚ F stops it completely, although many microorganisms can survive frozen storage.

Since most canned foods will be stored in the danger zone, an ideal preservation treatment is one that kills all pathogenic and spoilage organisms originally present in the food that are capable of growing in the finished product ("sterilization"). To achieve this end, it is important that strict time-temperature requirements be met. In other words, for successful preservation, every particle of food in a container must reach, and be held at, the specified temperature for the specified length of time.

The time required to raise food to the necessary temperature, and hold it there for a sufficient time to kill microorganisms, is affected by many factors. In general, low acid foods must be processed at higher temperatures and for longer times than acid foods.

Yeasts and molds are destroyed when food temperatures reach about 190˚ F. Most bacterial vegetative cells are destroyed at temperatures below that of boiling (212º F); however, the **higher temperature is required to ensure that all vegetative cells are destroyed.**

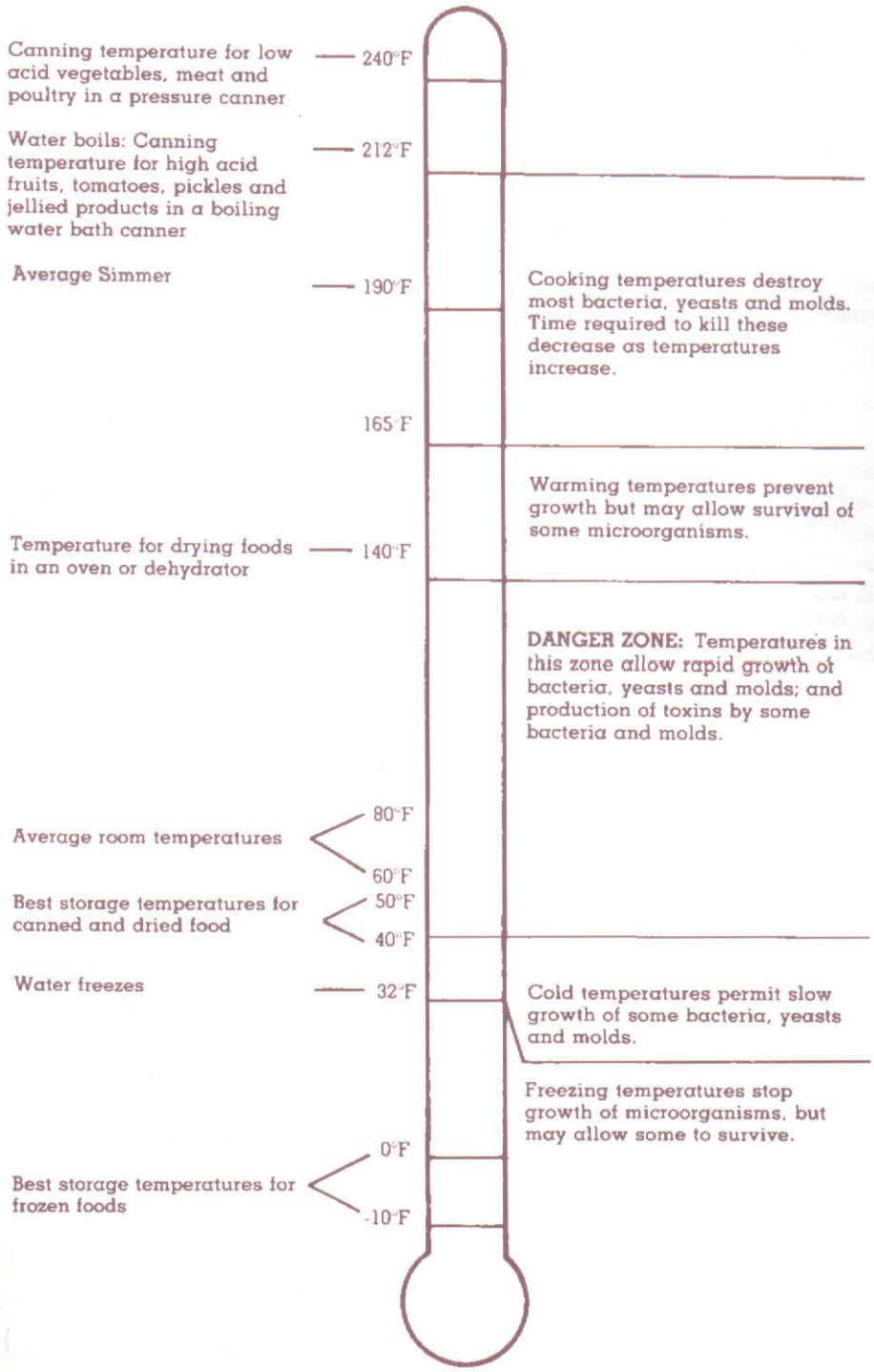
Certain kinds of bacteria are capable of producing heat-resistant spores (which may be likened to seeds) that can survive boiling water treatment (212˚ F) for long periods of time. However, spores are killed relatively rapidly at temperatures above the boiling point of water. To achieve these higher temperatures, the food must be processed under steam pressure in a pressure canner.

Pressure enables the processing of canned foods at temperatures higher than that of boiling water, and kill rates are greatly increased. Pressure canning is required to safely process foods that may support the growth of bacterial spores.

Clostridium botulinum is one such microorganism. While growing in food, this bacterium produces a toxin that is potentially lethal. To avoid the risk of serious foodborne illness, low and non-acid foods must be processed at temperatures above 212˚ F.

Some Factors Affecting Time Needed for Heat Penetration During Canning	
Factor	**Influence**
Container size	Larger size, more time needed
Heating medium (wet heat vs. dry air)	Wet heat allows more rapid heat transfer
Solid to liquid ratio	Decreased liquid proportion, increases time
Consistency of food	Generally, thicker food requires longer time
Fat	Generally, increased fat increases time
Initial temperature of food (cold raw pack vs. hot pack)	Cold raw pack takes food longer to reach proper temperature, especially in a boiling water bath canner.

Chart 2: Temperatures for Food Preservation



2. Water:

Water in fresh food exists in free and chemically bound forms. Microorganisms require free water for growth. Removal or reduction of free water from a food prevents the growth of microorganisms and controls enzyme activity. Water requirements of microorganisms are defined in terms of water activity or the unbound moisture (free or available water) of the food. Another part of the water is separated with difficulty and is referred to as bound water.

The moisture content of foods can be controlled by two basic methods:

1. by dehydration (removal of water)
2. by chemical control (making water unavailable)

This preservation principle is based on the fact that microorganisms require water to grow. Removal of water from food prevents the growth of most microorganisms and helps to slow down most enzymatic deterioration.

Dehydration is one of the oldest methods of food preservation. Preservation of foods by drying is a direct consequence of removal or binding of moisture which is required for growth of microorganisms. In New York State, foods other than herbs must be mechanically dehydrated.

Availability of free water in foods can also be controlled by adding compounds that chemically bind water, making the water unavailable for use by the microorganisms. The two most common home ingredients used to bind water are sugar and salt, as gelled products and brined pickles. Salt and sugar decrease the water activity by causing free water to bond to the sugar or salt. Use of sugar in jams and jellies and use of a concentrated salt solution in brining are effective methods of food preservation because they lower the availability of water enough to no longer support growth of microorganisms that cause food spoilage. Salt reduces the amount of available water more effectively than sugar does.

The amount of available water or water activity cannot be directly related to total water content; however, percent moisture is much easier to measure than water activity. The following tables relate the growth of microorganisms in terms of percent water, or salt, or sugar concentrations, which is a general guideline only. Water activity is measured using a scale of 0 to 1. A water activity of 1.0 relates to pure water. Even the driest foods have water activities much higher than 0.

Water Control Range	
The minimum moisture needed for growth of:	
Bacteria	35 percent
Yeasts	25 percent
Molds	15 percent

Water Activity		
Water Activity	Foods	Microorganisms
1.00 to 0.98	Fresh meat, fruit, vegetables, milk, canned fruit in light syrup, canned vegetables in brine	All foodborne bacterial pathogens and spoilage organisms grow rapidly
0.93 to 0.98	Processed cheese, tomato paste, cooked sausages, canned fruits in heavy syrup, bread	All foodborne bacterial pathogens can grow in at least the upper part of this range. *Listeria monocytogenes* may grow as low as 0.92 to 0.93
0.85 to 0.93	Dry fermented sausages (salami), aged cheddar cheese, sweetened condensed milk	*Staphylococcus aureus* is capable of growing in this range, mycotoxins (excreted by molds) can be produced in this range
0.60 to 0.85	Dried fruit, flour, cereals, jams and jellies, molasses, nuts, parmesan cheese	Pathogens do not grow in this range. Spoilage by molds and yeasts can occur in some products
Below 0.60	Candy, chocolate, honey, dried pasta, crackers, potato chips, dried egg, dried milk, dried vegetables	Microorganisms do not multiply at these water activities, but they can survive for long periods of time

3. Acidity

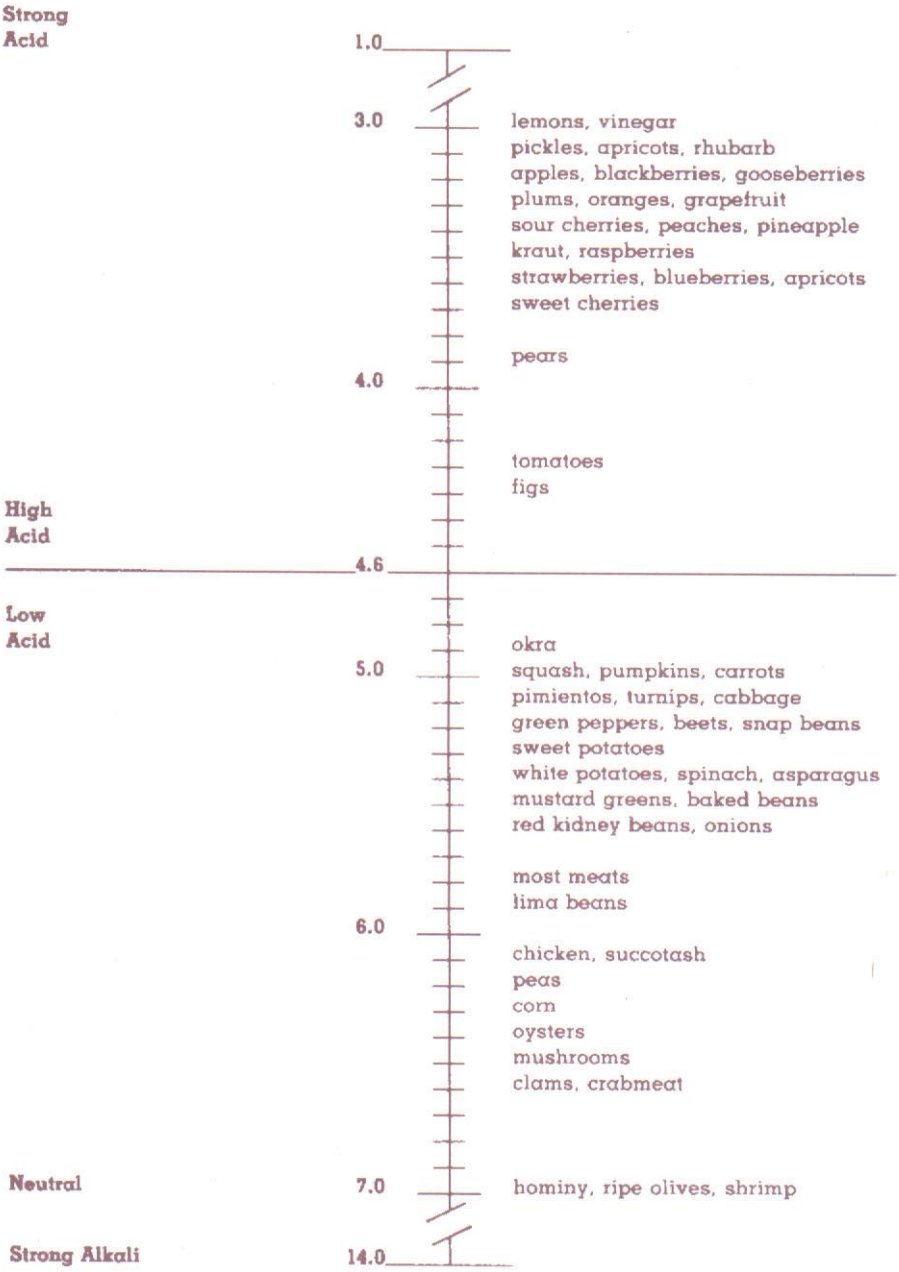
Most foods contain naturally-occurring organic acids, such as citric, malic, and ascorbic acids. Acid content varies greatly between various foods.

In the laboratory, acidity or alkalinity of foods is determined by measuring pH. The pH scale ranges from 0-14, with 0 being most acidic; 7, neutral; and 14, most alkaline. **In other words, the <u>higher</u> the acid level, the <u>lower</u> the pH.**

pH values reflect the actual acidity of products. However, because they are expressed on a logarithmic scale, the simple rules of arithmetic do not apply to pH. The pH value of an equal mixture of two foods cannot be predicted by adding the two pH values and dividing by two.

In food processing, the most important pH to remember is 4.6. *Clostridium botulinum*, the organism which produces the botulism toxin (poison), cannot grow below this pH. Foods that naturally fall below this pH are called “acid foods”. This level of acidity inhibits or prevents the growth of many microorganisms; however the presence of acids in foods does not kill organisms.

Chart 1: pH Value of Various Foods*



*Adapted from 1977 Yearbook of Agriculture

4. Oxygen

With proper canning practices, air is forced from the jars, leaving a vacuum. Molds and some yeasts are unable to grow in a vacuum. However, this means there is a very healthy growth environment for anaerobic bacteria (those bacteria that don't require oxygen to grow), in sealed, home canned foods. Such foods must be heat processed until a commercially sterile product is achieved. In home canning, products with sufficient salts, sugars, or acids must also be heat processed.

The presence of oxygen can also cause oxidation. Oxidation causes many color and flavor changes. The most common flavor change is referred to as old and/or rancid. Oxygen can also increase activity of many chemical substances in food, including enzymes which also cause food to spoil.

Food Preservation Methods & Microbial Control	
Preservation Method	**Means of Microbial Control**
Jams & Jellies	• Decreased water availability • Removal of oxygen (sealed jars) • Inactivation of microorganisms by high heat (adequately boiling water bath processed)
Canning of Fruits & Tomatoes	• Removal of oxygen (sealed jars) • Inactivation of microorganisms by high heat (adequately boiling water bath processed) • Acidity (natural or added)
Canning of Meats & Vegetables	• Removal of oxygen (sealed jars) • Inactivation of microorganisms by high heat (adequately pressure canned)
Pickling	• Increased acidity (fermentation or vinegar) • Removal of oxygen (sealed jars) • Inactivation of microorganisms by high heat (adequately boiling water bath processed)
Drying	• Decreased water content and availability
Freezing	• Decreased temperature

Cornell Cooperative Extension recommends using safe, tested canning recipes from the following sources:
National Center for Home Food Preservation http://www.homefoodpreservation.org
So Easy to Preserve, 5th Edition, Cooperative Extension University of Georgia
Ball Blue Book, 110th Anniversary Edition

Processing in a Pressure Canner

Canning is the process by which foods are placed in jars or cans and heated to a temperature that destroys microorganisms and inactivates enzymes. This heating and later cooling forms a vacuum seal. The vacuum seal prevents other microorganisms from re-contaminating the food within the jar or can.

The Pressure Canner is used to process foods under pressure which creates higher temperatures in the canner than can be achieved in a boiling water bath canner. The pressure most often used is 10 or 11 pounds, which creates a temperature of 240□F.

Pressure canning is the only safe method for processing low acid foods such as vegetables, meat, poultry, and fish. The pressure canner can supply enough heat to destroy the bacterial toxins that cause botulism as well as other types of spoilage. Failure to properly process low acid foods in a pressure canner can result in botulism which is often fatal.

Read your manufacturer's instructions concerning the operation of your pressure canner; however, only use canning recipes and timetables that have been approved by USDA and published after 1994.

The following are general instructions for using a pressure canner:

1. Place 2 to 3 inches hot water in the canner if you are canning raw packed foods. For hot packed food, the water may be gently boiling.
2. Set the jars of food on the rack in the canner so steam can flow around each jar.
3. Fasten the canner lid so that no steam escapes around the seal.
4. Make sure the vent (petcock) is open.
5. Turn burner heat to high, and watch for steam to escape in a funnel shape from the open vent.
6. Allow steam to escape for 10 minutes.
7. Close the vent, using a weight, valve or screw, depending on the type of canner. If it is a weighted gauge with varying pressures, be sure to use the correct pressure for the food.
8. For a dial gauge canner, let the pressure rise quickly to 8 pounds pressure. Adjust the burner temperature down slightly and let the pressure continue to rise to the correct pressure. (If the burner is left on high, it will be difficult to regulate the pressure once it rises.)
9. For a weighted gauge canner, let the canner heat quickly at first and when the safety lock engages adjust the burner heat down slightly until the weight begins to rock gently or "jiggle" 2 to 3 times per minute, depending on the brand of canner. Adjust the burner heat so as to have a continuous rocking or jiggling 2 to 3 times per minute. Start counting the processing time as soon as the weight rocks or jiggles.
10. Keep the pressure constant by regulating the heat. Do not lower the pressure by opening the vent or lifting the weight. Keep drafts from blowing on the canner.

Fluctuating pressure is one cause of liquid loss from jars (siphoning) and for dangerous under-processing.

11. When processing time is complete, carefully remove the canner from the heat. If too heavy, simply turn off the heat. Removing the canner from an electric burner is recommended.
12. Let the pressure in the canner drop to zero. This will take 30 to 45 minutes in a standard heavy-walled canner and nearly an hour in larger canners. Newer thin-walled canners depressurize more quickly. Do not rush the cooling process by setting the canner in water or running cold water over it. Never lift the weight or open the vent to hasten the reduction of pressure. Proper depressurization is important for the safety of the food.
13. When canner is depressurized, open the vent or remove the weight. Older canners are depressurized when the gauge on a dial gauge canner registers zero, or when a gentler nudge to the weight on a weighted gauge canner does not produce steam. Newer canners are equipped with a safety lock. These canners are depressurized when the safety lock releases. Sometimes safety locks located in the handle of the canner will stick. If a nudge to a canner weight indicates it is depressurized then run a knife blade between the handles to release the lock.
14. Wait 10 minutes, unfasten the lid and remove it carefully. Lift the lid with the underside away from you so that the steam coming out of the canner does not burn your face. Do not leave the canner unopened to completely cool. The food may spoil, and it may be very difficult to open the canner hours after it has cooled.
15. Use a jar lifter to carefully remove the jars as soon as the processing time and depressurization time is over. Place the hot jars right side up on a rack, dry towel, wood board, or layers of newspaper to prevent the jars from breaking contact with a cold surface. Leave at least 1” of space between jars.
16. Do not tighten rings.
17. Allow jars to cool untouched for 12 to 24 hours.

Finishing the Canning Procedure

The following information applies to both the boiling water canner or pressure canner method of processing.

1. Cooling Jars – Place hot jars on a cloth or rack so air can circulate freely around them. Keep hot jars out of cold drafts.
2. Jar lids should not be re-tightened after processing. As jars cool, the contents in the jars contract, pulling the self-sealing lid firmly against the jar to form a high vacuum. Most two-piece lids will seal with a “pop” sound while they’re cooling.
3. Testing for Seal - When jars are completely cool to the touch (about 12 hours), test each jar for a seal. Jars with flat, metal lids are sealed if:
   - Lid has popped down in center.
   - Lid does not move when pressed down with a finger.

- Tapping the center of the lid with a spoon makes a clear ringing sound. A dull thudding sound may indicate a weak seal or that food is touching the underside of the lid. To determine which, hold the jar up and look at it.

4. If a jar is not sealed, refrigerate and use it within 2 or 3 days. Other options are to freeze the contents (in a freezer container) or to reprocess the food within 24 hours of the initial processing.
5. To reprocess, start by removing the lid. Check headspace of food and liquid. Check the jar rim for damage. If no chips or nicks are on the sealing rim, the lid may not have been put on tightly enough or the lid may not have been prepared properly. Clean the sealing surface of the jar or replace the jar if damaged. Use a new lid and process for the full raw-pack time. After reprocessing, the food will be safe, however the quality will be diminished.

Storage

1. Remove, wash, dry and store metal screw bands in a dry place to retard rusting. Wash jars and label each jar with contents, date processed and lot number if more than one canner load was processed on the date. For best quality, store between 50ºF and 70ºF in a dry place to prevent the lids from rusting and possibly breaking the seal.
2. Before opening each jar, look for bulging lids, leaks and any unusual appearance of the food. After opening, check for off-odor, mold, foam or spurting liquid. Never taste questionable foods.
   Caution: To prevent the risk of botulism, low-acid and tomato foods not canned according to 1994 or more recent USDA-endorsed recommendations should be boiled even if you detect no signs of spoilage. At altitudes below 1,000 feet, boil foods for 10 minutes before tasting or eating. Add an additional minute of boiling time for each additional 1,000 feet elevation.
3. All low-acid foods canned according to the approved recommendations may be eaten without boiling, when you are sure of all the following:
   - Food was processed in a pressure canner.
   - The pressure canner gauge was accurate.
   - Up-to-date researched process times and pressures were used for the size of jar, style of pack, and kind of food being canned.
   - An approved recipe was used with no changes made in ingredients or proportions of ingredients.
   - The time and pressure recommended for processing the food at the canning location's altitude were followed.
   - Jar lid is firmly sealed and concave.
   - Nothing has leaked from the jar.
   - No liquid spurts out when jar is opened.
   - No unnatural or "off" odors can be detected.

References:
USDA's Complete Guide to Home Canning, 2006So Easy to Preserve, 5th Edition, Cooperative Extension Service, The University of Georgia, 2006
National Center for Home Food Preservation website: http://www.uga.edu/nchfp/

RECIPES

Meat Strips, Cubes or Chunks
(Bear, Beef, Veal, Lamb, Pork or Venison)

1. Choose high quality, chilled meat. Remove excess fat.
2. Strong-flavored wild meats should be soaked for 1 hour in a brine made from 1 tablespoon salt per quart of water. Rinse meat.
3. Cut into 1-inch wide strips, cubes or chunks.

Hot Pack Preparation

1. Pre-cook meat to the rare stage by roasting, stewing or browning in a small amount of fat.
2. If desired put ½ teaspoon salt in pint jars, 1 teaspoon in quart jars.
3. Pack meat loosely into hot jars, leaving 1-inch headspace.
4. Fill jar to 1 inch from the top with boiling meat juices, broth, water or tomato juice (especially for wild game.)
5. Remove air bubbles. Add more liquid if necessary.
6. Wipe jar rim. Place prepared lid on jar and hold in place with ring.

Raw Pack Preparation

1. If desired put ½ teaspoon salt in pint jars, 1 teaspoon in quart jars.
2. Pack raw meat into hot jars, leaving 1-inch headspace.
3. Do not add liquid.
4. Wipe jar rim. Place prepared lid on jar and adjust jar ring.

Process in a Dial Gauge Pressure Canner at 11 pounds pressure
OR in a Weighted Gauge Pressure Canner at 10 pounds pressure

Pints	75 minutes
Quarts	90 minutes

Altitude Adjustment

Dial Gauge Pressure Canner		Weighted Gauge Pressure Canner	
Altitude	Pounds or Pressure	Altitude	Pounds of Pressure
0 to 2,000 feet	11	1 to 1,000 feet	10
2,001 to 4,000 feet	12	Above 2,000 feet	15
4,001 to 6,000 feet	13		
6,001 to 8,000 feet	14		
8,001 to 10,000 feet	15		

Adapted from *So Easy to Preserve*, 5th Edition, Cooperative Extension University of Georgia.

Vegetable Soup (with or without Meat or Poultry*)

Ingredient preparation

1. Choose favorite soup ingredients of vegetables, meat, or poultry.
2. Do not include rice, noodles or other pasta.
3. Do not include flour, cornstarch or other thickener.
4. Do not include milk or cream.
5. Do not include pureed vegetables.
6. Dry beans and peas must first be rehydrated and then boiled for 30 minutes.
7. Partially cook all ingredients, adding salt if desired.
8. Combine ingredients and add hot water, broth, or tomatoes to cover.
9. Boil 5 minutes.

Canning procedure

1. Fill hot jars halfway with solid mixture.
2. Continue filling with hot liquid, leaving 1-inch headspace
3. Remove air bubbles. Add more liquid if necessary.
4. Wipe jar rim. Place prepared lid on jar and hold in place with ring.

Process in a Dial Gauge Pressure Canner at 11 pounds pressure
OR in a Weighted Gauge Pressure Canner at 10 pounds pressure

Pints	60 minutes
Quarts	75 minutes

* Cooked seafood may be added as part of the solid mixture, processing

Pints and Quarts	100 minutes

Altitude Adjustment

Dial Gauge Pressure Canner		Weighted Gauge Pressure Canner	
Altitude	Pounds or Pressure	Altitude	Pounds of Pressure
0 to 2,000 feet	11	1 to 1,000 feet	10
2,001 to 4,000 feet	12	Above 2,000 feet	15
4,001 to 6,000 feet	13		
6,001 to 8,000 feet	14		
8,001 to 10,000 feet	15		

Adapted from So Easy to Preserve, 5th Edition, Cooperative Extension University of Georgia.