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UNDERSTANDING HOME-SCALE PRESERVATION OF FRUITS AND VEGETABLES

PART I: Canning and Freezing

By

VITA Volunteer Eric Rusten

Technical Reviewers:

Joel M. Jackson
George Rubin
William G. Schultz

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Volunteers in Technical Assistance (VITA)
1815 North Lynn Street, Suite 200
Arlington, Virginia 22209 USA
Telephone 703/276-1800
Cable VITAINC
Telex 440192

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PREFACE

This paper is one of a series published by Volunteers in Technical Assistance (VITA) to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteers technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Margaret Crouch as project manager, Suzanne Brooks handling typesetting, layout, and graphics, and James Butty as technical writer/editor.

The author of this paper, VITA Volunteer Eric P. Rusten, a former Peace Corps Volunteer to Kenya and Nepal, is a graduate student at Washington University in St. Louis, Missouri. The reviewers are also VITA Volunteers. William G. Schultz is a mechanical engineer and has specialities in food processing applications; George Rubin is a product developer with Dell Products Incorporated in New Jersey, having retired as manager of the Welch Foods Inc. in Westfield, New York; Joel Jackson is a food scientist with Food Preservation Systems in Windsor, Maryland.

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I. INTRODUCTION

Preserving the surplus food that is often available at harvest time helps ensure a continuous supply of food throughout the year. There are several methods of food preservation, including canning, freezing, pickling, drying, and curing (smoking or salting). All these preservation methods aim to prevent or at least slow down spoilage. Careful attention to the proper techniques of preserving and storing also helps ensure that the food stays as nutritious and palatable as possible.

This paper, the first of a two-part series, discusses principles of canning and freezing fruits and vegetables at home, for home use. The companion paper presents the principles of drying and curing. Guidelines are given to help readers select the best possible method of preserving the produce they have available.

Drying, smoking, salting, and pickling have been used for thousands of years to keep food from spoiling. Canning or jarring to preserve food is much more recent. It was first developed in 1809 by Nicholas Appert, a French chef who learned that food cooked in sealed containers would keep for extended periods of time. Although Appert, like his predecessors, did not know why food spoiled or why their technique worked, this early method was quite successful and has changed little since it was developed. Today, it is one of the most popular methods of preserving food. In the early twentieth century, freezing became a popular method for short-term preservation of food, but its high cost has kept it from becoming as common as canning in many parts of the world.

II. FOOD SPOILAGE

WHY FOODS SPOIL

The rotting of fruits and vegetables has four major causes. Three of these--molds, yeasts, and bacteria--are microorganisms found in great numbers in the air, soil, and water. They are the primary causes of food spoilage. Enzymes, the other major cause of food spoilage, are complex chemical substances found in all living cells, including the skins and flesh of fresh fruits and vegetables. All preservation methods are aimed at preventing these four agents from acting upon the food being preserved.

Molds

Molds are fungi that grow in warm, moist food. As the mold grows, it slowly consumes the food matter and brings about changes in the character of the food. This promotes the growth of other microorganisms, eventually leading to complete food spoilage.

The ideal temperature for mold growth is between 10 and 38°C (50-

100°F). But at temperatures of 90°C or more, all molds and yeasts are destroyed, except for a few rare, heat-resistant species.

Yeasts

Yeasts are another type of fungi. They act upon starches and sugars to produce alcohol and carbon dioxide in the process of fermentation. The ability of yeasts to bring about fermentation makes them very valuable organisms for the production of bread, beer, and wine. But they can cause food to ferment even when it is not desired, making the food unfit for consumption. This type of food spoilage can be prevented by reducing the moisture content of the food and raising or lowering the temperature beyond the point required for yeast growth.

Bacteria

Bacteria are microscopic organisms that exist almost everywhere. Some bacteria are beneficial in that they help in the production of certain foods. For example, cheeses are made by the action of certain bacteria on milk. Yet others are harmful because they contribute to food spoilage or produce poisons that can cause serious illness and even death when ingested.

Some spoilage-causing bacteria can be killed at the same temperatures that destroy yeasts and molds. Others must be heated to temperatures as high as 116°C (240°F) for as long as 20 minutes. Keep in mind that cooking time lengthened as altitude increases.

Where food preservation is concerned, the most dangerous of all bacteria is the one that causes botulism, a disease that is often fatal. Botulism-causing bacteria are naturally found in the soil. They thrive at moderate temperatures between 21° and 43°C (70° and 120°F) and can be easily introduced into food through contaminated utensils, soiled hands, or polluted water.

Botulism-causing bacteria can be destroyed by heat at temperatures above boiling, at least 116°C (240°F), for up to 20 minutes. This type of bacteria can survive, grow, and reproduce only in moist environments at room temperature, and in the absence of air. These are the exact conditions present in cans or jars where food is preserved by the canning process.

Properly canned food should be safe from botulism poisoning, since both the poison and bacterium are destroyed by boiling for 15-20 minutes. But if canned food should ever smell bad when opened, it should be discarded to avoid being eaten.

Enzymes

Enzymes are organic compounds classified as proteins. They function as chemical catalysts in the cells of plants and animals

and are essential for normal growth and development. However, after a fruit or vegetable is picked, its enzymes slowly stop functioning in their normal constructive way and start to break down the plant tissue. If this action is not slowed or halted, the produce will start to decompose and eventually spoil. It is therefore necessary to slow or stop the action of enzymes if fruits and vegetables are to be preserved successfully.

Enzyme action requires specific environmental conditions within the cell. These include narrow ranges of temperature, moisture, and acidity. If any of these conditions is significantly changed, the action of the enzyme can be altered. For example, enzyme action slows down at lower temperatures and increases at temperatures slightly higher than normal. Some enzymes are destroyed when plant tissue is heated above 54°C (130°F). But many, including some that contribute to browning of foods, may not be destroyed at temperatures less than 90°C.

CONTROLLING SPOILAGE

Besides temperature and moisture, two other factors affect the actions of food spoiling agents. The first is cleanliness, the act of working with food only under sanitary conditions. This involves cleaning all foods thoroughly before preserving them, keeping hands and work area clean, and washing all equipment used in the preservation process in boiling water. If proper care is taken to keep everything very clean, food that is preserved should keep for many months, remaining tasty and nutritious.

The second factor in controlling food spoiling agents is the level of acidity of the food being preserved. Many of the microorganisms that bring about spoilage are very sensitive to acidity and cannot live in highly acidic environments. These spoiling agents can be controlled by increasing the acidity of the environment. Some fruits and vegetables are naturally acidic and therefore are easier to preserve. Foods with the acidity measurement of 4.5 or higher are considered to be low in acid. Beans, corn mushrooms, pumpkin, white potatoes, etc., are some examples of common low-acid fruits and vegetables. On the other hand, foods with acidity measure of below 4.5 are regarded as strong in acid content. Some examples of high acid fruits and vegetables are lemons, grapefruits, oranges, tomatoes, pineapples, etc. It is important to remember that varieties of the same food will have different ratings, as will identical varieties grown under different conditions.

III. FOOD PRESERVATION METHODS

The major methods of fruit and vegetable preservation are canning, pickling, drying, freezing, and curing (smoking or salt-

ing). Whatever method of preservation you choose, keep in mind that preserved food is only the next-best alternative to fresh food, not a replacement. Whenever a fruit or vegetable is preserved some of the food's nutritional value is lost, along with some of its natural flavor, color, and aroma. For this reason, only the freshest and best quality fruits and vegetables should be used for preservation.

CANNING

Canning is practiced in many parts of the world. Even though it seems quite complicated at first, canning is easy once a person becomes familiar with the process.

Canning uses heat to bring about sterilization and the exclusion of air for preserving fruits and vegetables. Heat sterilization destroys the microorganisms that cause spoilage or poisoning in food. Exclusion of air forces air out of the food, thus creating an airtight seal. Two methods are used to sterilize the food, the water bath, and the pressure cooker. In the water bath process, the jars of food are submerged in water in a large kettle and allowed to boil for a specified period of time. The pressure cooker method, which must be used for safe handling of low acid foods, uses a pressure canner instead of a kettle to achieve the higher temperatures that are necessary.

After freezing, canning is the most expensive home method of preserving fruits and vegetables. However, it is one of the best methods of preserving products that are to be stored for long periods of time. Most of the expense involved in canning is the initial investment in canning jars and other equipment that may not be on hand in the home. Once all of the materials are bought, canning becomes much less expensive, since the costs are averaged over time. When compared to the cost of fruits and vegetables purchased during off-season or those commercially canned, the cost of home canning often is inexpensive.

The Principles of Canning

Only fresh, undamaged fruits and vegetables should be selected for canning. They should be carefully trimmed, cleaned, and cut into pieces of the desired size for preserving. The food is then packed into jars either hot (hot packing) or raw (cold packing). The method used depends on the type of fruit or vegetable being preserved and the recipe being followed.

Fruits and vegetables that are fairly delicate in nature are often packed raw because they tend to keep their shape better with this method. After being carefully but firmly packed into the jars, some type of boiling liquid, specified by the recipe being followed, is poured over the produce. Firmer fruits and

most vegetables are often pre-cooked before packing (hot-packed), since they take up less space in the jars after being cooked. Usually, hot-packed produce has a shorter processing time than cold-packed produce since the food has already been cooked. The time required for pressure canning is not shortened much at all.

Regardless of which packing method is used, it is important to leave a small amount of air space--about one to three centimeters deep--between the food and the jar lid. It is also advisable to cover the food completely with liquid to prevent its exposure to the air, which may discolor it.

Water Bath Process. If the cold pack, or water-bath, canning method is being used, the packed jars, with their tops put in place but not sealed tightly, are placed on a shallow rack in a large pan filled with warm water (never place cool jars in boiling water or they may break). Add enough water to completely cover the jars of food by at least three to five centimeters. As the water in the water-bath boils, any air in the jars or food will be expelled. This helps to create a vacuum, thus enabling the jars to seal tightly.

After the appropriate processing time, the jars are allowed to cool for a minute or two in the water. They are then lifted out of the hot water and dipped into cold water. Dipping secures the seal by increasing the vacuum.

When the jars are completely cool, they are labeled with the name of the produce and the date canned, and carefully stored away in a cool (between 4 and 21^{o}C or between 40 and 70^{o}F), dark place to retard the loss of nutrients.

Pressure Process. To process low acid fruits and most vegetables, it is necessary to use a pressure canner instead of a water-bath canner. Read carefully any canning instructions provided by the manufacturer of the pressure canner being used. First, pour water into the pressure canner to a depth of about four centimeters. Next, carefully place the jars on the rack and seal the pressure canner. Heat the pressure canner on a cookstove for several minutes, until steam leaves the vent at the top of the pressure canner's cover. Then fix the weighted gauge over the vent.

After the appropriate cooking time for the food being processed, let the pressure canner cool until the inside pressure, indicated by the gauge, falls to zero. Then gently raise the gauge slightly off the vent to release excess steam from the pressure canner. Open the pressure canner by lifting the lid away from you so that you will not be burned by any remaining hot steam.

Remove the jars, and let them cool until they can be touched. Then carefully place them in cold water to complete the sealing process. Finally, label the jars and store as described earlier.

Equipment and Materials Required

Much of the equipment required to can fruits and vegetables may already be present in many homes. The amount of equipment to be purchased depends upon how much canning will be done and what fruits and vegetables will be preserved. The following is a list of basic equipment often needed to can fruits and vegetables:

- A large tall cooking pot for water-bath canning (See Figure 1). The pot should be either stainless steel or an enameled metal. Aluminum or iron pots will corrode when they come in contact with the acidic juices from fruits and vegetables. The pot should also be 7.5 to 12.5 centimeters deeper than the jars used to contain the food.

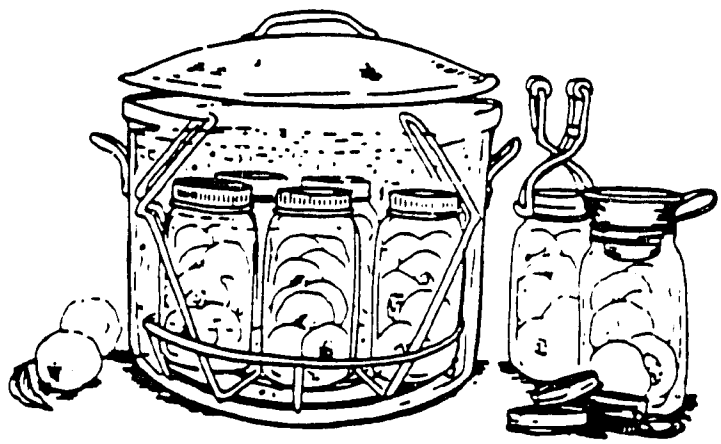

Figure 1: Water Bath Canner

- A pressure cooker or pressure canner (see Figure 2) for canning low-acid foods. This should be large enough to hold at least four quart jars. Although a large pressure cooker can be used, canning experts recommend using a pressure canner since it is designed and constructed specifically for canning.

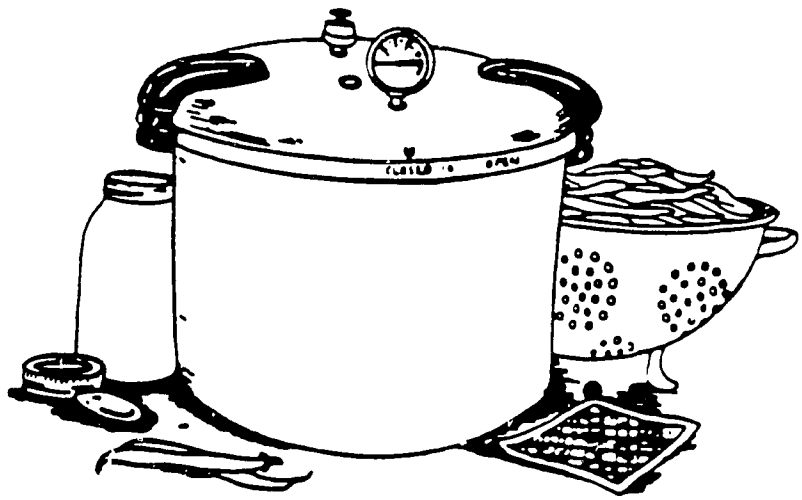

Figure 2: Gauge-Type Pressure Canner

- Jars that are in very good condition with tight-fitting lids and seals.

- Cheese cloth or a wire basket to hold food for straining and blanching (dunking fruits and vegetables in boiling water or exposing them to steam).

- Large spoons and a ladle, made of wood or stainless steel, and a selection of knives and smaller cooking pots.

- A wide-mouthed funnel for filling jars.

- Something with which to lift jars out of the cooking pot or pressure canner (special tongs may sometimes be available).

- Measuring spoons and cups, and a timer.

In addition to this equipment, some type of cookstove will be needed to heat the water-bath canning pot or pressure canner.

The Pressure Canner. The most expensive piece of equipment aside from the cookstove is the pressure cooker or pressure canner. Whether or not this is needed will depend upon the acidity of the fruits or vegetables to be canned. The pressure cooker is required for low-acid foods (all vegetables except tomatoes), but it is not necessary if only high-acid foods such as tomatoes and most fruits are to be canned.

The pressure canner is the only type of cooking device that can destroy the bacteria spores responsible for producing botulism poison. The pressure canner pressurizes the boiling water, allowing the temperature of the steam inside to reach temperatures as high as 121°C (250°F). Because of the high pressure and temperature produced by the pressure canner, it is very important to follow the manufacturer's instructions carefully and keep the vent and safety valve unclogged and clean.

The Jars. Special care also needs to be taken in the selection of canning jars, since faulty jars may lead to spoilage of the preserved food. If possible, jars made specifically for home canning should be used. The cost of the jars could be expensive, but when averaged over the many years that they can be used, their relative cost becomes much lower. Most beginning canners may find it necessary to start with a relatively small number of jars the first year and then add more jars each successive year. This will help reduce initial expense and make the first year's work a little easier.

Most canning experts advise against using jars that have previously been used to store commercially canned produce. According to these experts, such jars are designed to be used only once and are not as sturdy or well made as jars manufactured specifically for home canning. In addition, commercial canning jars are often difficult to reseal once the jars have been opened. This leads to

contamination and spoilage of the canned produce. Commercial jars can be used for some applications, such as the canning of jams and jellies, since they are used only as containers and do not play a critical role in the preservation process.

Three general types of jars are made specifically for home canning: a jar with porcelain-lined zinc cap and rubber ring closure; a jar with a screw band and self-sealing lid; and a jar with glass lid, rubber ring, and wire-clamp fastener. Examples of these jars are shown in Figure 3. All canning jars have the advantage of being usable over and over again. Only the rubber seal or self-sealing lid needs to be replaced after each use.

Figure 3. Canning Jars

Source (all Figures): Preserving Summer's Bounty, by Marilyn Kluger. New York: M. Evans and Company, Inc., 1978.

Labor Requirements

Canning is not overly complicated, but it requires careful planning and execution if it is to be successful. Since it is best to can only fresh, undamaged fruits and vegetables, canning needs to be done during peak harvest times, when a sufficient supply of produce is available. The number of workers and the amount of time needed to process the produce depend upon the quantity of fruits and vegetables that can be processed. Generally, home canning can be accomplished by as few as one or two people, and each canning session may last from four hours to all day. Canning time also depends upon the number of jars of produce that can be processed by either the pressure canner or the water-bath canner at each heating; a larger canner permits the processing of more jars at one time. To keep the time required for canning to a minimum, it is important to make sure that all the equipment and materials needed are clean and ready for use.

Remember that water-bath canning time lengthens as altitude increases. Therefore it is important to adjust cooking time with altitude changes.

Energy Requirements

Canning is second only to freezing in terms of the quantity of commercial energy required, but this amount is relatively small. Although it is possible to heat both the pressure canner and the water-bath canner over a wood fire, it is much more convenient to use kerosene, gas, or electricity, and the amount of heat generated is much more easily controlled.

There are essentially three steps in the canning process that require energy use. The first is the cleaning of the canning equipment, jars, lids, and seals with scalding water. Depending on the recipe being followed, some fruits and vegetables will also need to be blanched (dipped in boiling water for a short period of time to retard or stop the destructive action of enzymes) or precooked before they can be processed. This is the second step of the canning process that requires the use of energy. Finally, all produce must be processed in either a pressure canner or water-bath canner. The quantity of energy used in each of these steps depends primarily upon the amount of produce being processed.

Cost/Economics

To determine whether canning is an economically viable method of preserving produce for a specific family, it is necessary to compare the costs and benefits of canning against other alternatives. For example, it is important to compare the costs of canned produce with the average yearly cost of fresh produce. When doing this, it is also helpful to spread the cost of the equipment, jars, and other utensils over several years, not just the year of purchase or for a single year of canning. Most of this equipment can be used year after year, and usually for more than just canning. This makes canning less expensive.

Generally, fruits and vegetables are least expensive and most readily available during peak harvest, which is not only the best time to eat fresh produce, but the best time to preserve it for later use. Preserved produce has its greatest value during the off-season when fresh fruits and vegetables are either not available or are very expensive.

Another important consideration is the cost involved in the loss of fruits and vegetables due to spoilage. People who have gardens often harvest more than they can either consume or sell. Preserving this surplus is likely to be more economical than letting it spoil. In addition, having a variety of canned fruits and vegetables on hand for year-round consumption adds diversity to meals, and improves a family's diet. The economic advantage of a better diet may be difficult to estimate, but it should be obvious to everyone.

It is also important to compare the cost of home-canned produce to that of commercially canned produce. When making this comparison, it is important to consider not only the price difference but also the probable difference in quality. Home-canned produce is often of higher quality and superior flavor than commercially canned food. In addition, if you are considering home-scale canning, you need to weigh the costs and benefits of this method against other preservation methods for home use.

Finally, you should consider the value of your time. Is canning your own food the best way to spend your time, especially if you must also work full time at a job, in the fields, or elsewhere? You may not have choice--preserving your own foods may be the only way to assure an adequate diet for your family in the off season. But your time is important, and it should be calculated.

Advantages and Disadvantages

The advantages and disadvantages of home-scale canning depend upon the type of produce being preserved, the conditions of the specific locality, and the skills and resources of the people who will be doing the work. There are some general points, however, that should be considered. Canning, like all preservation methods, prevents the unnecessary loss of food due to spoilage. This enables people to eat specific fruits and vegetables year-round, thus improving the character and quality of their diets. Canned produce is easy to store, and it also retains much of the natural flavor, color, and nutritional value of the fruit or vegetable. One of the biggest advantages of canning over other preservation methods is that at meal time canned produce is quick and easy to prepare since it has already been cleaned, cut, and in many cases cooked. Properly canned food also has a shelf life ranging from six months to several years, depending on the type of food.

On the other hand, canned produce, like all preserved produce, suffers some loss of vitamins and other nutrients. But the loss of only a small portion of the nutritional value of a food is of little consequence when compared to not having any of the food or nutrients available at all.

The biggest disadvantage of canning is the high initial cost of all the equipment needed to start a home-scale canning operation. This may prohibit some people from using this technique. An additional disadvantage for some people may be the difficulty of acquiring the pressure cooker or pressure canner that is needed to can low-acid foods. The special jars needed to can properly on the home-scale may also be difficult to acquire in some areas. The energy demands of canning may also prove to be a disadvantage to some, and therefore a less energy-intensive preservation method may need to be chosen.

Maintenance Requirements

Little more than cleaning is needed to maintain a good canning operation, but the value of this cannot be overstressed. The cleaner the equipment, jars, produce, kitchen, and work surfaces, the better the results. The old saying, "An ounce of prevention is worth a pound of cure," is very appropriate for successful canning.

Since the jars are one of the most important parts of the entire canning process, they should be examined very carefully before being used. Any chipped or damaged jars should be discarded along with any imperfect rubber rings or lids. A defective jar, lid, or seal could lead to contamination and spoilage, and even botulism poisoning. If a pressure canner is used, it is very important to follow the maintenance instructions provided by the manufacturer.

Variations and Alternatives to Home-Scale Canning

One possible way to overcome the problems of high initial cost is to establish a cooperative canning center. Through a cooperative effort, a group of people could combine their financial resources to purchase a large water-bath canner and pressure canner, as well as other utensils. This may result in significant savings. Also, if enough people are involved in the cooperative canning center, the cost of the jars may be reduced by buying in large quantities.

Communities that already have agricultural cooperatives will probably have little difficulty getting such a community canning center started. Before this type of cooperative can be established, however, it is important to address some basic questions. First, are there enough people in the community interested in canning fruits and vegetables? Second, is there a building available for such a cooperative to use? Since canning is generally a seasonal activity, there is no need to have a permanently established kitchen. Third, is there someone in the community with the skills to supervise the activities of the cooperative and keep the necessary financial records? If positive answers to these questions can be found, there is a good chance that a cooperative canning kitchen could be established.

FREEZING

Freezing involves lowering the food temperature below the freezing point of water ($0^{o}C$ or $32^{o}F$). For the initial freezing of fruits or vegetables, it is important to lower the temperature of the produce to between -15^{o}-$20^{o}C$ (-5^{o}-$0^{o}F$) as quickly as possible. For quicker freezing, fruits and vegetables should be spread out individually on trays in the freezer so air can circulate freely. The more rapid the freezing process, the fresher

tasting the final product. Once the food is frozen, it should be packaged and then stored at about -20°C (0°F).

Generally, fruits and vegetables are each prepared differently for freezing, but in all cases, only fresh, undamaged produce should be selected for freezing.

Equipment Needed

Freezing fruits and vegetables requires equipment such as a freezer or access to frozen food cooler, food containers (jars, plastic boxes, heavy plastic bags), waxed paper boxes, blanching kettle, strainers, a timer, etc.

Freezing Fruits

Fruits are usually not blanched or cooked before they are frozen to allow them to retain their garden-fresh flavor. Fruits such as peaches are an exception to this rule because their peels are much easier to remove after blanching.

There are two basic ways to pack fruits. The first and simplest is the dry pack method: the fruit is just put whole or cut and peeled into containers and then placed in the freezer. In some cases, it is better if the fruit is allowed to freeze first before it is packed so that it will not stick together in the container. The advantage of this packing method is that the fruit can be used a little time.

The second way to pack fruits, and probably the preferable way for most fruits, is the wet pack method in which the fruit is packed along with some liquid, usually sweetened. For fruits that are naturally juicy, all that may be needed is to add some sugar. The sugar not only sweetens the fruits but draws out their natural juices, which results in the formation of a sweet syrup. After all the sugar is dissolved, the fruit can be packed and frozen. Other fruits can be frozen after a cold sugar syrup is poured over the packed fruit. Plain fruit juice and water can be used in place of a sugar syrup if the extra sweetening is not desired.

Freezing Vegetables

Vegetables, like fruits, are prepared for freezing by cleaning, cutting, and peeling. Unlike most fruits, however, vegetables must be blanched in boiling water for a few moments and then quickly dunked in very cold water. Blanching maintains quality and slows enzyme activity. It also softens the vegetables, making them easier to pack. Before packing and freezing, they should be thoroughly drained. If wet vegetables are placed in the freezer, they stick together and frost will form in the container. Most vegetables are packed in containers without adding anything extra. This allows them to be used as if they were fresh produce.

Care of Frozen Food

It is important to remember that unfrozen food should not be piled together in the freezer. Instead it should be spread out along shelves so that it will freeze as quickly as possible. All packaged fruits and vegetables should be carefully labeled with the amount of produce, the name of the fruit or vegetable, and the date. Labeling makes it easier to identify the contents of each package. Finally, food stored in the freezer should be rotated so that the oldest food is eaten first. This will prevent food from being held in the freezer for too long. Dating packages ensures that the oldest frozen produce will be used first. Note that frozen produce generally has a maximum storage life of one year. Longer storage will not make foods unfit for use, but may reduce quality.

As a general rule, foods that have been completely thawed should not be refrozen because they may become sources of food poisoning and because quality is reduced. More information about the freezing requirements for varieties of fruits and vegetables can be found in many guide books on food preservation.

Labor Requirements

As noted, freezing is the simplest, quickest, and easiest method of preserving fruits and vegetables. Home-scale freezing can easily be done by one person, although two or three people can of course be involved. The fact that only small batches of fresh produce are frozen at any one time makes the job less tiring.

Energy Requirements

The amount of electricity required to operate a freezer depends upon the model and age of the freezer, its usage, and the outside temperature. Usually, a freezer is a fairly expensive piece of equipment to own. Energy use can be slightly reduced by keeping the freezer as full as possible (jugs of water can be used to occupy spaces not taken up by food) and opening the door as infrequently as possible. Freezers that keep frost from accumulating, i.e., frost-free freezers, use more energy than regular freezers, if the regular freezer is periodically defrosted.

The only other stage in the freezing process that uses energy is the blanching of vegetables. If the produce is well prepared in advance, energy use can be kept to a minimum.

Cost/Economics

The main expenses associated with freezing are the initial cost of the freezer and the daily cost of the energy needed to keep it running. Both of these costs may equal the value of the time saved in the preparation of the produce for freezing, along with

the ease of preparing the frozen food for the table. If the costs of the freezer and electricity run second to the value of the time and energy required to prepare produce for preservation, and the character of the preserved fruits and vegetables is of prime concern, freezing may be the best method.
Finally, the Asian Institute of Technology in Bangkok, Thailand, has developed an experimental freezing unit that runs on solar energy instead of electricity. At present, this system is much too large and expensive to be used in the home. It is probable, however, that inexpensive home-scale solar-powered freezers will be developed in the future.

Advantages and Disadvantages

The major advantage of frozen produce is that it retains much of its original fresh flavor, color, and nutrients. It is also quick and easy, requiring little preparation, and the final product is superior to other produce preserved using other methods. On the other hand, the disadvantage is the cost involved in the purchase and operation of the freezer. Another disadvantage is having to deal with a freezer full of thawing food in the event of a power outage or freezer failure.

Maintenance Requirements

Except for cleaning the equipment used to prepare the produce for freezing, there is little regular maintenance. If the freezer is not self-defrosting, it must be periodically defrosted. Defrosting is necessary for two reasons. First, as frost builds up it takes up valuable space in the freezer that could have been used to freeze fruits and vegetables. Second, frost build-up reduces the cooling efficiency of the freezer. Regardless of what type of freezer you own, it is important to follow maintenance suggestions provided by the manufacturer of the freezer.

Alternatives to Home Freezing

In some situations, it may be possible to rent storage space in a large commercial frozen food locker instead of buying a freezer. This may be a good way for people to become familiar with the freezing method before actually committing themselves to an expensive piece of equipment. However, a disadvantage of renting freezer space outside the home is the added difficulty of having to transport the prepared fruits and vegetables to the freezer and then bring them back home when they are needed.

IV. CHOOSING THE PRESERVATION METHOD RIGHT FOR YOU

It is unlikely that only one of the four preservation techniques --canning, freezing, drying, or curing--would be the only suitable method. Therefore, a food preparation system should be de-

veloped that matches your particular situation. Such a system should consist of a combination of methods that are appropriate for the different types of fruits and vegetables to be preserved. It should also meet the available resources and the specific needs of the individuals involved.

The two most dominant constraints affecting the type of preservation system that can be used are the availability of capital and the cost and availability of a constant supply of commercial energy. These constraints essentially group the four different preservation methods into three primary systems:

1. Where commercial energy and money are readily available, system one, comprising all four methods, can be used.

2. Where sufficient energy but only a moderate supply of money are available, system two, comprising canning, drying, and curing, can be used.

3. Where energy is either lacking or very expensive, and money is in short supply, system three, comprising drying and curing, can be used.

Secondary constraints are also important for determining which preservation method or methods can be used. For example, the following questions should be addressed in deciding which of the four methods or system to use. The brief discussion following each question points out many factors that must be considered before a decision can be reached.

- How long will the food need to be preserved? If relatively short-term preservation is desired (six months to a year), and easy preparation is an important concern, then freezing may be the best choice.

- How much food needs to be preserved? If only a relatively small amount of food needs to be preserved, then freezing may be the best choice. On the other hand, if quantities to be preserved are larger than available freezer space, canning, drying, and/or smoking may be better choices.

- Are the proper jars for canning available along with other necessary equipment? If so, and large quantities of food need to be preserved, then canning may be the best choice.

- What fruits and vegetables need to be preserved? Some fruits and vegetables respond better to specific preservation methods. Some may turn to mush if frozen; canning may have the same effect on others. To decide which method or methods would be most suitable for a specific vegetable, it is best to consult one of the books listed in the bib-

liography, or seek help from the government agricultural office, a high school, or a university.

- Is a special or unique taste treat desired? If so, then canning or pickling may be better choices, since both are used to make specialty foods.

- How much previous experience with food preservation do you have? If the answer is little or no previous experience, then maybe the least complicated method should be tried first. It is a good idea to master this method before advancing to more complicated and difficult procedures.

- What is the weather like during peak harvest time? If it is sunny, dry, and windy, then preserving with a solar dryer may be a good choice, provided it also meets all other preservation requirements.

- How many people are available to help with a large quantity of fruits and vegetables? If only one or two family members will be involved in food preservation, it might be best to select a method, like freezing or curing, that can be done in the shortest amount of time with the fewest number of people.

- Which preservation method do you like best? Trying out different methods on a variety of fruits and vegetables will enable you to develop your own preferences. At this point, it is important to note that determining a preservation method requires careful consideration of many variables that make up a situation. In most cases, though, there is a significant amount of leeway open to the individual in selecting the appropriate preservation method.

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VI. SUPPLIERS AND MANUFACTURERS

Dixie Canner Equipment Company
786 East Broad Street
P.O. Box 1348
Athens, Georgia 30601 USA
(Can Sealers)

Food Preservation Systems
P. O. Box 188
New Windsor, Maryland 21776 USA
(Canning Equipment)

Freund Can Company
155 West 84th Street
Chicago, Illinois 60620 USA
(Cans and Sealers)

National Presto Industries
Eau Claire, Wisconsin 54701 USA
(Pressure Canners)

Refrigeration Engineering Corporation
8799 Crownhill
P. O. Box 3-C
San Antonio, Texas 78217 USA
(Freezers)