TECHNICAL PAPER # 60

UNDERSTANDING HOME-SCALE PRESERVATION OF FRUITS AND VEGETABLES PART II DRYING AND CURING

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Understanding Home-Scale Preservation of Fruits and Vegetables
Part II. Drying and Curing

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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.

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VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers.

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 as possible.

This paper, the second of a two-part series, discusses principles of drying and curing (smoking or salting) fruits and vegetables at home, for home use. The preceding paper looked at the principles of canning and freezing. 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[degrees]C (50-100[degrees]F).
But at a temperature of 90[degrees]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[degrees]C (240[degrees]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[degrees] and 43[degrees]C (70[degrees] and 120[degrees]F) and can be easily introduced into food through contaminated utensils, soiled hands, or polluted water.

Botulism-causing bacteria can be destroyed by heating them to temperatures above boiling, at least 116[degrees]C (240[degrees]F), for up to 20 minutes. It is important to note that 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[degrees]C (130[degrees]F). But many,

including
some that contribute to browning of foods, may not be destroyed
at temperatures less than 90[degrees]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 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 measurement 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 salting). 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.

DRYING FRUITS AND VEGETABLES

Drying fruits and vegetables to retard or prevent spoilage has been practiced in many parts of the world for thousands of years. Sometimes known as sun drying, this process involves laying produce out in the sun until it becomes suitably dry, and then storing it in containers for later use.

The basic principle behind drying fruits and vegetables is to remove between 80 to 90 percent of the water from the produce, thereby creating an environment that cannot support microbial life. Also, as water is removed from the plant's tissues, salt, sugar, protein, and other solutes increase in concentration. This is an additional factor that prevents the growth and reproduction

of microorganisms that may cause spoilage.

Several factors are important when considering drying as a possible method for preserving fruits and vegetables.

o Dried fruits and vegetables taste different from fresh, canned, or frozen produce, even when they are reconstituted by adding water before they are eaten. People who are not in the habit of eating dried produce may need some time to get used to the different tastes.

o Exposing fruits and vegetables to sunlight and heat will result in the loss of some vitamins. The longer the exposure time, the greater the loss of nutrients. This partial loss of vitamins from the produce can be reduced through careful pretreatment before drying and during the drying process.

o The various nutrients in dried produce are highly concentrated because of the removal of most water from the tissues of a fruit or vegetable. In other words, 500 grams of fresh apples will have less nutritive content than 500 grams of dried apples.

o Some fruits and vegetables are easier to dry than others. For example, apples, apricots, coconuts, dates, figs, guavas, and plums are fruits that dry quite easily, while avocados, bananas, breadfruit, and grapes are more difficult to dry. Most legumes are easily dried, as well as

chilies, corn, potatoes, cassava root, onion flakes, and the leaves of various herbs and spices. On the other hand, asparagus, beets, broccoli, carrots, celery, various greens, pumpkin, squash, and tomatoes are more difficult to dry successfully. If done with the help of solar energy, the drying of fruits and vegetables is the least expensive of food preservation methods.

o Produce that has been dried sufficiently and stored in airtight containers stays fresh for about six months to a year, depending on the storage containers used and the type of produce preserved.

Methods of Drying

There are essentially three different ways to dry fruits and vegetables. First and most basic is simple sun drying, where produce is simply laid out in the sun to be dried. There is no pretreatment, and no special devices are used to assist the drying process. The second method, solar drying, again makes use of the sun's energy to help dry the fruits or vegetables. However in this method, the produce is usually pretreated to prevent discoloration and retard vitamin decomposition, and housed in a special structure to aid the drying process. In the third method, the produce is pretreated, and placed in a special drying device that uses commercial energy as its source of heat. All of these methods, although similar in some respects, do require slightly different materials and equipment, and therefore each will be treated separately.

Sun Drying. To sun-dry fruits and vegetables, you need a clean, flat surface, plenty of sunlight, and warm, dry air. This method has been used for thousands of years. But there are several drawbacks. First, it takes a significant amount of time to completely dry the fruit or vegetables. Second, while the produce is drying, it is exposed to airborne pollutants so that the final produce will most likely not be very clean.

Solar Drying. On the other hand, solar drying overcomes these difficulties by placing the prepared produce on trays made of non-metal material, and then placing the trays in a structure covered with glass or plastic. An example of a simple solar dryer is shown in Figure 1. Since a solar dryer depends upon sunlight,

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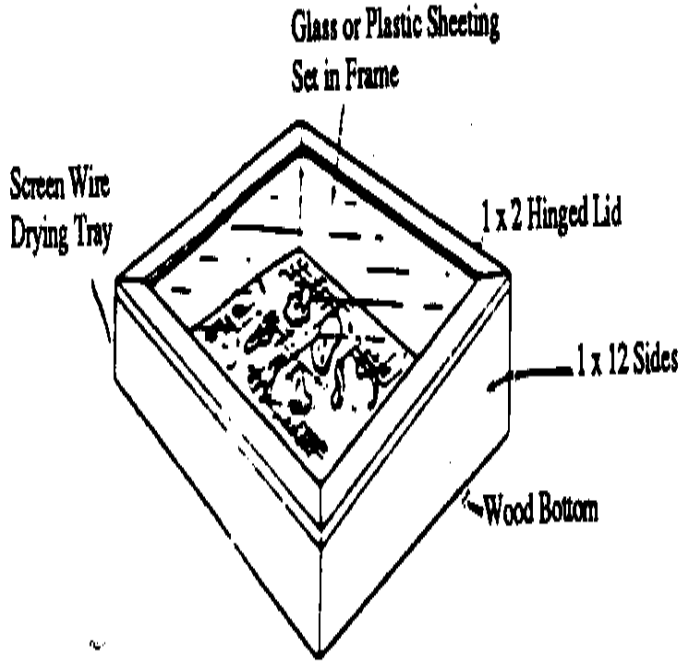

Figure 1. A Cold-Frame Solar Dryer

Source: Ruth Hertzberg, Beatrice Vaughan, and Janet Greene, Putting Food By, (Brattleboro, Vermont: The Stephen Greene Press, 1975), pg. 327.

it costs essentially nothing to operate. However, solar dryers can be used only when sunlight is intense and the air relatively dry. Depending upon the types of fruits and vegetables being

dried and the temperature and humidity of the air, it can take from one to three days to completely dry produce.

Convection Drying. Both of these problems--the need for sunlight and the slow drying time--can be overcome by using a convection dryer, which does not depend on sunlight to dry the produce. By using a commercial source of energy such as electricity, gas, or kerosene, the amount of heat entering the dryer can be closely regulated and maintained at an optimum level (30-60[degrees]C or 86-140[degrees]F),
thereby keeping drying time to a minimum. Moreover, since fruits and vegetables are not exposed to sunlight during the drying process, they retain more of their vitamins. A low-cost, kerosene-heated dryer is shown in Figure 2. One of the disadvantages

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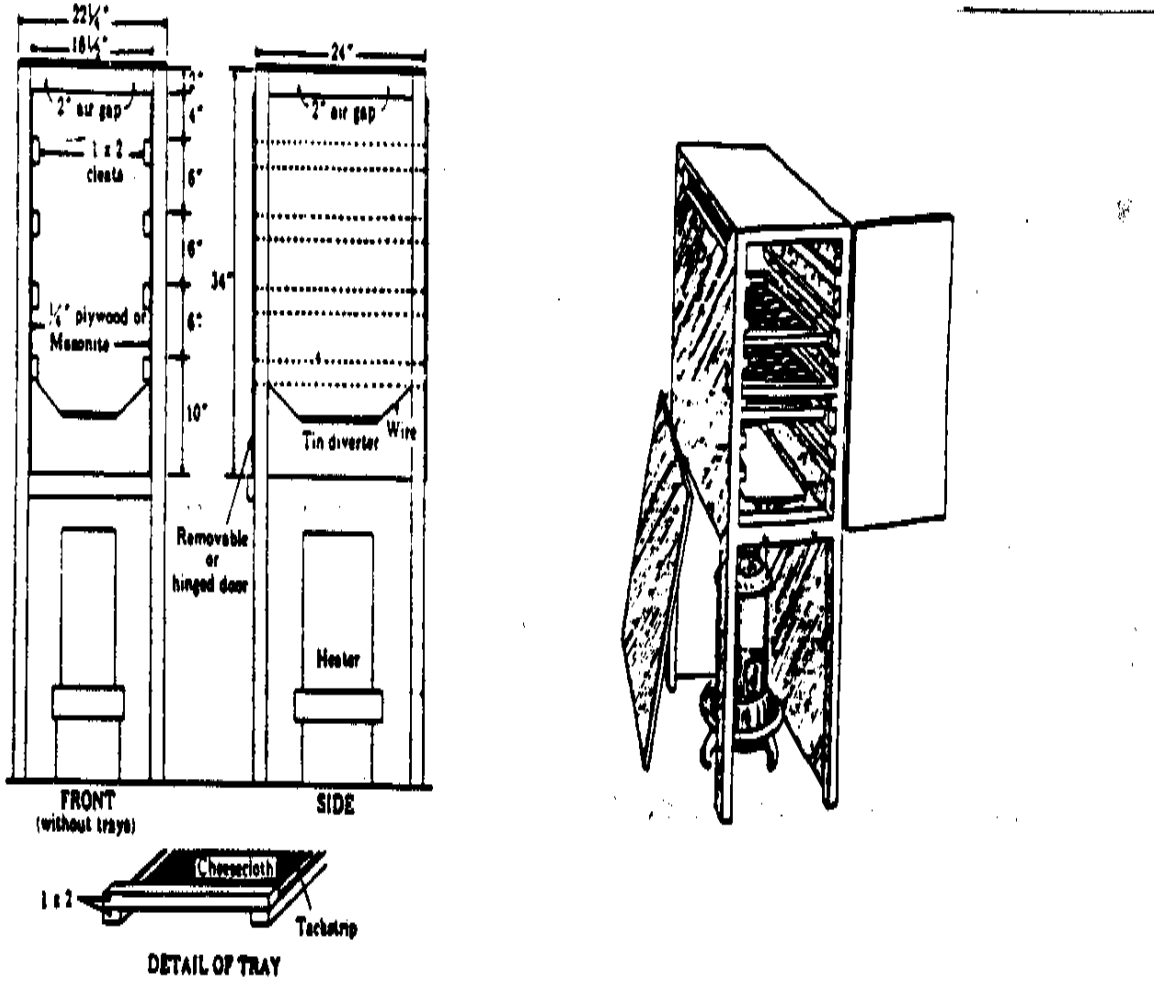

Figure 2. A Low-Cost Kerosene-Heated Dryer

Source: Stocking Up: How to preserve the foods you Grow, Naturally, by Carol Stoner (Emmaus, Pennsylvania: Rodale Press, 1977).

of drying produce in a convection dryer is the high cost of the energy required to operate the dryer.

Each of the preceding methods requires that the fruits and vegetables undergo some form of preparation before being dried.

Equipment

The equipment and materials needed to prepare produce depend partially on the type of produce being processed, but primarily on whether pretreatment against discoloration, vitamin loss, and contamination is carried out. If the produce needs only to be dried so that it can be stored for a few months and the color of the dried fruit is of little concern, very little equipment will be needed other than knives to slice and peel the produce.

On the other hand, if you want to store dried produce longer than one or two months, and you also want to prevent discoloration and retard vitamin loss while the produce is being dried, more equipment and materials will be needed. Such equipment includes:

o A medium to large cooking pot (between 4 and 8 liters in volume) in which to blanch the produce if needed;

o A large basin or plastic bucket (about 10 to 20 liters in volume) in which to soak the produce in an anti-discoloration solution;

o Another large basin or plastic bucket in which to soak the produce in a sulfite solution to combat vitamin loss and contamination;

o A wooden fume box in which to sulfurize the produce, if a better treatment method against vitamin loss is desired;

o Some sublimed sulfur (99.5 percent pure) or a powdered sulfite compound such as sodium bisulfite or potassium metabisulfite, if the produce will be sulfurized. However, sulfite has been found to cause allergic reactions in a small percentage of people and should be used with care.

o Some ascorbic acid (vitamin C) or lemon juice to make the anti-discoloration solution, if the produce will be pre-treated against discoloration.

o Storage containers (glass jars with tight-fitting lids work best; sturdy plastic bags also work well).

It is not difficult to construct a fruit and vegetable dryer, but care must be taken in selecting the construction materials. Be sure to choose a wood that will not discolor the produce or impart an off flavor to it. A local carpenter could probably advise on most suitable woods. In addition, it is important never to use any metal materials for dryer parts that will come in contact with the fruits or vegetables. The acidic juices from some fruits and vegetables will corrode many metals, resulting in the probable loss of the produce being processed and the slow deterioration of some dryer parts.

The Drying Process

For most fruits and vegetables, drying is accomplished by increasing the air temperature to between 33[degrees]C and 60[degrees]C (91[degrees]F-140[degrees]F), to stimulate evaporation. This temperature is also the ideal temperature for the growth and reproduction of many spoilage-causing microorganisms. As a result, both spoilage and loss of vitamins may occur. To avoid this, it is essential to dry the produce as quickly as possible.

The rate at which fruits and vegetables dry depends on three major factors. First, drying time is lengthened if the produce has a very high water content, a small surface area, or a waterproof skin. Second, drying time is increased if the relative humidity of the air is high. In other words, if the air already holds nearly all the water it possibly can, it will be unable to take on much more, and the fruit will not be able to lose enough moisture to become dehydrated. Third, as water evaporates from a piece of fruit or vegetable, the air surrounding the food becomes saturated with water, causing the rate of evaporation to slow down and eventually stop. To prevent this from happening and to keep the rate of evaporation as high as possible, it is essential that air be kept in constant motion near the fruit to carry away the moisture-laden air. so, to increase the rate at which fruits and vegetables dry, force warm, dry air over produce being prepared to enhance the evaporation of water.

As with other preservation methods, it is essential to dry only fresh, undamaged fruits and vegetables. Following this rule will

reduce the chances of spoilage during drying and storage. After the best produce is selected, it must be cleaned thoroughly and in most cases sliced, peeled, and cored, if necessary. Water lost from produce during drying causes the produce to shrink significantly. As a result, most fruits and many vegetables should not be sliced too thinly. The best procedure for each type of fruit or vegetable can be determined either by the trial-and-error method, or better yet, by following drying instructions for the specific fruit or vegetable as outlined in a drying guide book.

Pre-Treatment. Before placing fruits or vegetables on drying trays, you may want to preheat them. In general, fruits and vegetables make a better product if they undergo one or more of the following pre-drying treatments: anti-discoloration, dewaxing, or sulfurization. Choice of pretreatment method, if any, depends on whether the benefits outweigh the costs.

The flesh of many fruits and vegetables turns a rusty, brown color when exposed to air. To prevent sliced produce from discoloring during drying, you need to soak the produce in an anti--discoloration solution. This solution can be prepared either by dissolving one to three teaspoons of pure ascorbic acid (vitamin C) in about one cup of water, or by squeezing the juice from several lemons into a cup of water. The amount of ascorbic acid or the number of lemons needed for a specific type of fruit or vegetable can be determined by trial-and-error. This solution should then be sprinkled over the produce soon after it has been peeled, pitted, and sliced. An alternative method is to pour this concentrate into a shallow basin half-filled with water. The

produce can then be soaked in the solution.

The skins of some fruits such as cherries, figs, grapes, prunes, and other berries are not only relatively tough, they are also covered by a thin wax-like coating that inhibits drying. If the skins are not weakened and their wax coatings removed, the drying rate will be significantly retarded. Both of these problems can be solved by quickly dunking the fruit first in boiling water, then in cold water.

The final pretreatment process is sulfurization. Pretreating fruits and vegetables with sulfur preserves their color. In addition, it helps retain vitamins A, B1, and C and inhibits the growth of microorganisms in the produce during the initial stages of the drying process. Note, however, that sulfurization is optional, since food safety depends mainly on how successfully the produce is dried. There are two ways to sulfurize produce. The first method, which is relatively easy and quick, involves soaking the prepared fruit in a sulfite solution. To make the solution, add between 1.5 and 3.5 teaspoons (about 5-10 grams) of sodium sulfite, sodium bisulfite, or potassium metabisulfite to four liters of water. Then, soak the produce in the solution for about 15 to 30 minutes.

The second method, which involves sulfurizing produce in a fume box (Figure 3), is considered by some experts to produce better,

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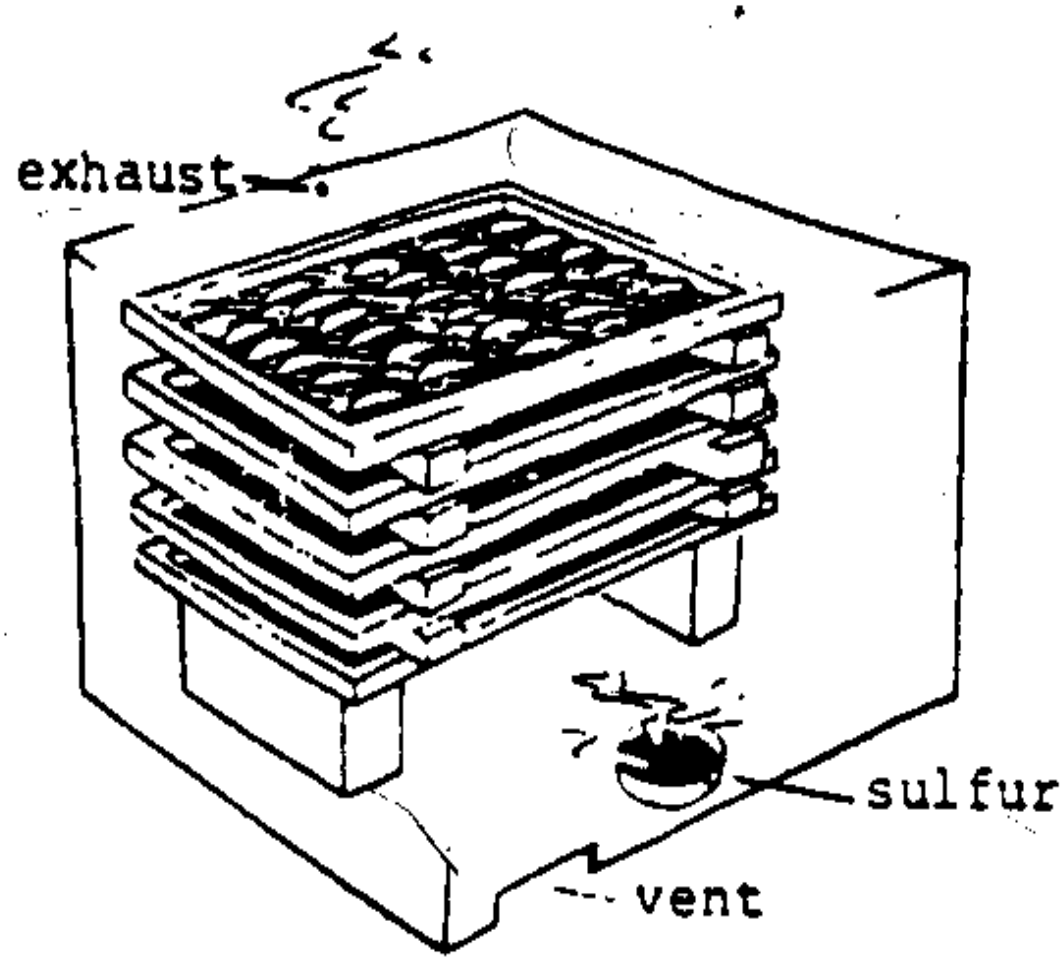

Figure 3. A Fume Box

results. In this method, a small amount of pure powdered sulfur---about

one teaspoon
(approximately 3 grams)
for every 500 grams of
produce--is burned in
the bottom of a large
fume box containing
stacked trays of fruits
and vegetables. Once
the sulfur has completely
burned, both
vent holes in the box
should be sealed.

The produce remains inside the box for at least 20 or 30 minutes before it is removed for drying. When removing the produce from the box, it is a good idea to stand so that the wind blows away from the box, thereby blowing the sulfur dioxide fumes away from you. The trays of produce should then be loaded directly into the dryer for drying.

Care of Dried Foods. Each fruit and vegetable has a different appearance and texture when it is thoroughly dried. Generally, a fruit is sufficiently dried if no moisture is visible when the fruit is cut. Most recipe instructions for drying specific fruits and vegetables include a test to determine whether the produce is completely dried.

After the produce is dried, it should be left to cool (if necessary) on the trays. Pour the dried produce into a large, open

container, preferably plastic or enameled metal. Cover the container with a porous cloth so that air can circulate, then place the container in a warm, dry area with good air circulation. Leave the produce in the container for at least 10 days, stirring at least once a day. This process, called conditioning, is done to distribute the remaining moisture evenly in the produce, thus reducing the chance of spoilage, particularly from mold. Freshly dried fruits and vegetables can be added to the container, but only during the first few days of conditioning.

After the produce is completely dried, it can be packaged and stored. It is important to let the produce cool completely before placing it in either plastic bags or glass jars. No special jars are needed to store dried fruits or vegetables, but tightfitting lids are essential if the produce is to be kept in good condition for any length of time.

Labor Requirements

The complete process of drying fruits and vegetables can be divided into two major activities: (1) produce preparation and pretreatment, and (2) drying. Produce preparation and pretreatment is more labor-intensive, but it can be done by one or two people, if only a moderate amount of produce (10-50 kilograms) is processed. To reduce the amount of time and effort involved in this activity, all equipment and materials must be cleaned before the preparation and pretreatment of the produce begin. Since several stages in this activity involve letting the fruit or vegetables either soak in a solution or sit on a tray, it would

be possible to set up an assembly line preparation system, if sufficient personnel and drying space were available. This would make the best use of the equipment and time available, and would enable a large amount of produce to be processed in a relatively short period of time.

Once the produce is in the dryer, relatively little work needs to be done, except to clean all the preparation equipment. If the produce is being dried with a solar dryer, it may be necessary to periodically adjust the placement of the dryer to take advantage of the sun's position. If a convection dryer is used, it may also be necessary to periodically check the setting of the heat-producing element. It will also be necessary to check the contents periodically (no matter which dryer is used) to see how the drying is progressing. It may also be necessary to shift the trays around in the dryer so that all the produce dries evenly.

Energy Requirements

Aside from blanching (quickly heating produce in boiling water), both sun-drying and solar dryers use no commercial energy. This makes them not only inexpensive but useful in areas where commercial sources of energy are either very costly or not available.

Unlike solar dryers, convection dryers do require commercial energy. The quantity needed depends upon the amount and type of produce being dried and the relative humidity of the surrounding air. Generally, convection dryers either run on commercial electricity or they are heated by means of a stove or portable heater,

using gas or kerosene. Although the temperatures required to dry fruits and vegetables are low, a significant amount of energy will be consumed because of the long time required to heat the dryers. Convection dryers should probably be used only if there is an inexpensive and reliable supply of energy available.

Cost/Economics

The principal advantage of sun-drying is that it costs nothing, since it uses solar energy, a free, limitless energy source that is also non-polluting. Food dried in the open, however, may be exposed to animals and insect pests unless, it is covered with some sort of cloth net (e.g., cheesecloth) or a fine-mesh screen.

Although no costs are associated with the operation of a solar dryer since it also uses energy from the sun, the principal disadvantage is the cost of either buying or building such a device. This may be expensive initially, but since it can be used year after year with little need for repairs or maintenance, the average lifetime expense should be very low.

Compared to open sun-drying, solar dryers use the sun's energy more efficiently, making it possible to dry produce in a shorter period of time.

If a convection dryer is used, there is the added disadvantage of having to pay for the commercial energy required to run the dryer. Energy costs may be offset, however, because the dryer does not require sunlight; it can be used at night or in cool,

rainy weather.

The only other probable expense, except for storage containers, will be the purchase of chemicals required to pretreat produce. This cost should be relatively low, however, since only small amounts are needed to process a fairly large quantity of produce.

Advantages and Disadvantages

In general, drying fruits and vegetables is a very effective way to preserve produce. Dried produce has the advantage of being very light in weight and low in volume and therefore easy to carry and store. The majority of dried fruits need no special preparation since they can be eaten in the dried state. Also, they are a highly concentrated source of nourishment and energy since most of the water has been removed. Preparing dried produce that can be eaten straight from the jar is usually a simple matter of either adding boiling water and stirring, or cooking the dried food until it is soft. This reconstituted produce can then be eaten as is or mixed with other foods.

The difference in taste between fresh and dried fruits and vegetables may be a slight disadvantage in some cases, but in most it should not be a problem. In fact, some dried fruits may be more flavorful than fresh fruit.

The time required to dry fruits and vegetables properly and the resulting loss of vitamins pose two major disadvantages that need to be carefully considered. Another important factor to consider

is the relative complexity of the pretreatment procedures involved in preparing fruit and vegetables for drying. Some people may also find it difficult to purchase the chemicals needed for this stage, and some may actually find it difficult to either buy or build a solar dryer. one final disadvantage of solar drying is that you are at the mercy of the weather. Successful outdoor drying is possible only in regions with prolonged sunshine and low humidity.

Convection dryers have one major advantage over solar dryers or sun-drying and that is, drying can be carried out around-the-clock for days. Unlike solar dryers, convection dryers are not subject to daily and seasonal weather variations.

But convection dryers are not without any problem. The fuels burned in convection dryers may cause other problems. Use of wood may contribute to problems of deforestation. Coal may cause pollution; fossil fuels are becoming increasingly expensive and are not always available.

Maintenance Requirements

The equipment used to dry fruits and vegetables requires little more than simple cleaning. This maintenance task should not be ignored since clean equipment will reduce the risk of contaminating the produce being dried. Special care should be taken with the cleaning of the dryer. As fruits and vegetables are processed, their juices will undoubtedly drip onto the drying trays and other parts of the dryer. If the trays are not cleaned after each

use, microorganisms will quickly start to grow and multiply. This may contaminate any new produce placed on the trays. In addition, the corrosive nature of some juices may contribute to the decomposition of the trays and dryer.

Maintaining a solar dryer involves checking the parts periodically for wear and tear. For example, make sure that vents are not blocked. Plastic sheeting may need to be replaced once a year because it scratches easily and tends to become brittle and cloudy from prolonged exposure to sunlight. The wooden cabinet of a homemade solar dryer will also need to be painted periodically to prevent the wood from weathering.

If a convection dryer is used, follow the maintenance instructions provided by the manufacturer. This will ensure that the dryer remains in good working order for many years.

Alternatives to Home-Scale Drying

Forming a food-drying cooperative is a good way to defray the costs of processing fruits and vegetables. Such a cooperative could possibly have several dryers built and then work as a team to dry everyone's surplus produce. This should allow more people to benefit from preserving fruits and vegetables and permit the drying of greater quantities of produce for each member.

A food-drying cooperative could easily become part of an existing farmers' cooperative or women's organization. If successful, the cooperative could even rent its drying services to other members

of the community, and in doing so pay for the equipment used to prepare and dry the produce.

CURING

If surplus fruits and vegetables cannot be preserved by canning, drying, or freezing, they most likely can be preserved by curing. This method of food preservation uses salt (either dry or made into a brine solution), vinegar, oils, and/or smoke to create an environment that retards or prevents the growth of spoilage-causing microorganisms.

Salt is the primary ingredient used in the curing process. It has the ability to draw water out of the food, and when used in high concentrations inhibits the growth of many living organisms. In small concentrations, it provides the conditions that promote the growth and reproduction of lactic-acid-producing bacteria. As the numbers of these bacteria increase, the amount and concentration of the acid they produce also rise. Eventually, the level of acidity exceeds the tolerance of not only all harmful bacteria, but also the lactic-acid formers themselves.

Along with drying, curing is one of the oldest methods of preserving produce. But cured produce, especially salted or brined foods, can be preserved and stored for longer periods of time. Although some fruits can be preserved by curing, this method is most commonly reserved for vegetables, since the flavor of many vegetables is fairly compatible with salt and vinegar. For this

reason, this section of the paper will refer primarily to the curing of vegetables.

Curing is a relatively easy method of preserving produce, and since it does not require a lot of equipment or supplies, it is also rather inexpensive. Most cured vegetables are stored in jars similar to those used in canning, and in some cases, the vegetables are heated in a water-bath canner to assure their full preservation.

Equipment and Materials Required

Since it is easier to cure relatively large quantities of produce, it is helpful to have several large stoneware crocks or some other large container that can hold at least 20 liters of material and that is unaffected by the action of salt or strong acids. Since vegetables may be soaked in a brine solution, it will be necessary to have something to cover the vegetables with, like a plate or a latticed wooden cover. A heavy weight will also be needed to hold the vegetables under the brine solution. It may also be helpful to cover the crock with a large piece of cheesecloth to keep insects from fouling the curing solution.

Standard kitchen implements will be needed to prepare the vegetables for processing. The following items should be kept on hand: measuring cups and spoons, knives, a cutting board, large spoons, large glass or enamel pans or bowls, a piece of cheesecloth for straining, and a scale to weigh the vegetables. once the curing process is finished, the produce will need to be

stored in jars similar to those used in canning. Some cured vegetables also need to be boiled in a water-bath canner, so for these you will also need a large kettle.

If the vegetables are to be smoked, it will be necessary to either buy or build a smoke box in which the vegetables can be hung and exposed to the thick curing smoke.

Each curing method and recipe will require different ingredients and spices. For example, a fine-grained, iodine-free noncommercial salt will be needed for salt curing, while vinegar with an acid concentration of between 4 and 5 percent will be needed for pickling, and wood and wood chips for smoking.

Curing Methods

As with all preservation methods, only fresh undamaged produce should be used in curing. Once selected, it should be carefully cleaned and either left whole or cut into the desired sizes for preservation.

There are three main methods of curing produce: salting, pickling, and smoking.

Salting. Salting is the process of curing vegetables in salt, which inhibits the growth and action of spoilage-causing microorganisms. Vegetables are salt-cured in one of two ways: by dry-salting (salt plus juice drawn from the vegetables by the salt) or brining (salt plus water). The amount of natural juice in the

vegetables determines whether they need to be dry-salted or brined. Vegetables are brined whenever they do not release enough natural juice to form the sufficient amount of liquid required for curing. Vegetables with plenty of natural juices, like corn, green snap beans, greens, or cabbage, can be dry-salted.

Vegetables such as cabbage or white turnips are often fermented to give them a slightly sour flavor. If you want to cure your vegetables this way, simply use one-tenth the quantity of salt needed for salting. This comes to about 300 grams of salt for each 12.5 kilograms of vegetables, although the ratio may vary depending on the recipe being followed. The smaller quantity of salt stimulates the growth of the lactic-acid-producing bacteria that not only cause fermentation but also prevents the growth and activity of harmful bacteria.

To increase the storage life of vegetables, pack them into glass canning jars, and boil in a water-bath canner.

Pickling. Pickling generally makes use of vinegar in place of or along with salt to cure vegetables, although some pickle recipes call for just brine or vegetable oil. The procedure for pickling is quite similar to brine-curing, with specific recipes requiring special spices, varying quantities of vinegar or salt, and slightly different instructions.

Smoking. Although smoking is used primarily to cure meats and fish, it can also be used to preserve vegetables. Smoke-cured vegetables have a unique flavor and may be mixed with other foods

or eaten plain. The easiest way to smoke vegetables is to slice them if needed, tie the pieces together on a long piece of string, and hang the vegetable braid over an open fire. Using an open fire is convenient only if the fire is also used to cook or keep the house warm. Otherwise, it would be better to build a simple smoke box (Figure 4) for outdoor use only.

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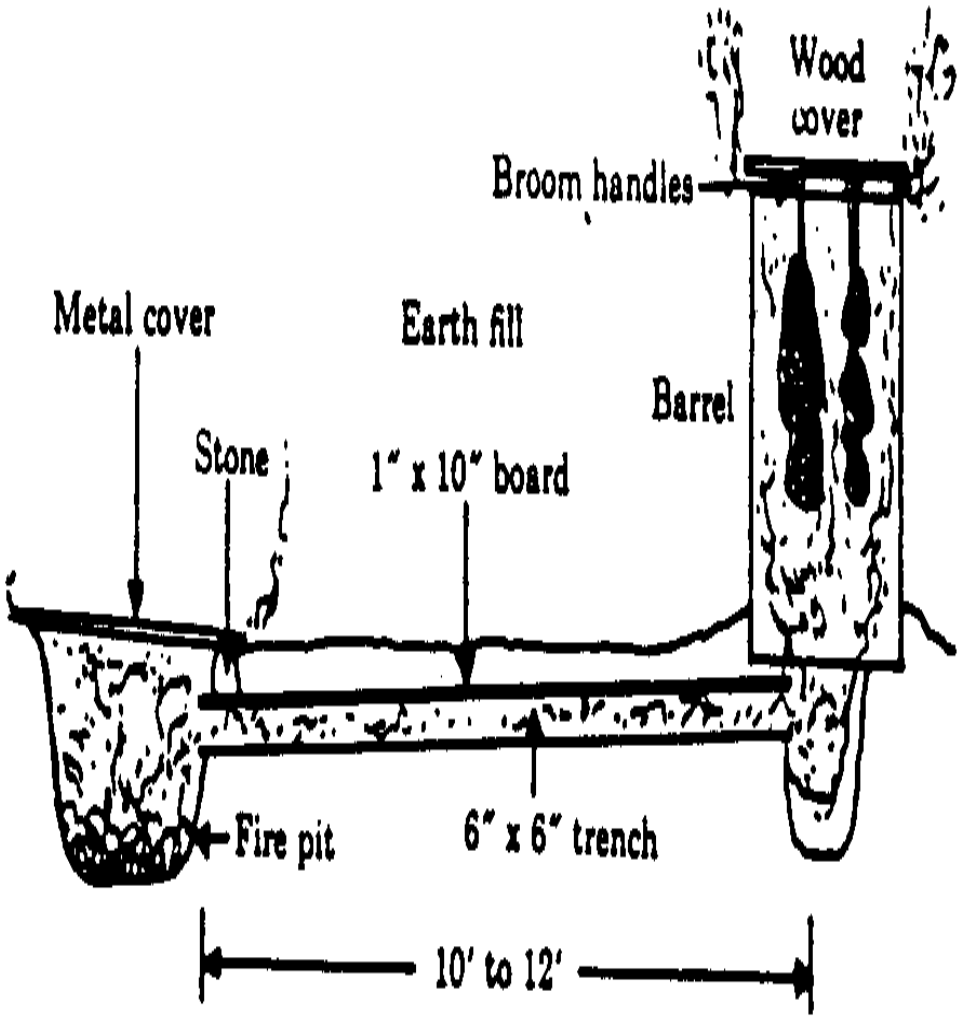

Figure 4. A Smoke Box

Some vegetables need to be oiled, spiced, and slightly salted before being smoked; others need no pretreatment. After they are

smoked, they can be stored in cloth bags or glass jars.

You can build a simple smoke box from a barrel. Dig the fire pit at least 10 inches from the barrel and connect the two with a pipe or tile trench.

Labor Requirements

Curing is one of the easiest preservation methods to perform because it requires a small amount of time and effort. Only one or two people are needed to preserve a relatively large quantity of produce. If all the necessary materials are on hand, the vegetables can be prepared, packed in crocks, and set aside in as little as three to five hours, depending upon the quantity of vegetables. After this first stage of the process is completed, it is necessary to examine the curing vegetables periodically and remove any scum that may have accumulated. Also, if the cured produce will be kept for long periods of time, it will be necessary to pack the vegetables in jars and process them further by heating them in a water-bath canner.

Energy Requirements

Besides being relatively quick and easy to do, curing also uses very little, if any, commercial energy. In the first stage of the salt and pickling processes, only the blanching of the vegetables consumes any energy. If the cured vegetables are packed in jars and processed in a water-bath canner, a little more energy will be needed. Finally, if vegetables are cured by smoking, fuelwood

will be needed, but if the vegetables are hung over a fire already being used for another purpose no additional energy will be used. Only a small amount of wood is needed to run a smoking box, since only a small smoldering fire is used. After all is considered, curing is one of the least energy-intensive preservation processes.

Cost/Economics

The economic advantages of curing vegetables are essentially the same as those for other preservation methods. However, curing may be one of the best methods to preserve a temporary surplus of vegetables for a few months. The raw materials needed are usually inexpensive and can be easily acquired, and the process is relatively quick and easy to accomplish. If the objective is to do more than just cure vegetables--that is, if you want to put cured vegetables through the canning process in the interest of extending their storage life--the costs will rise because of the increased energy use and the need for canning equipment and storage containers.

Advantages and Disadvantages

Curing fruits and vegetables has four primary advantages: it is relatively inexpensive; it is quick; it is easy to do; and it can turn an otherwise bland-tasting product into something more flavorful. In addition, it is a viable alternative for people who may not have the money or equipment to preserve fruits and vegetables any other way.

A major disadvantage of salt-cured vegetables is the need to wash the salt out of them before they can be eaten. Also, too much salt in one's diet is not healthy, especially if other health problems exist. It may also be difficult or even impossible for people living in warm tropical regions to keep the curing and pickling crocks in a relatively cool place.

Maintenance Requirements

Because curing is a relatively simple preservation method, there is very little maintenance required other than routine cleaning of all equipment. For salt and brine curing, there is the need to periodically remove the scum from the surface of the curing crocks, and the replacement of the covering cloth whenever it becomes soiled. If the cured produce is canned as necessary, jar lids will need to be replaced as necessary, and the jars themselves inspected for any chips or cracks.

Alternatives to Home-Scale Curing

If fruits and vegetables are to be smoked, it might be less expensive and more convenient for a group of people to build a smoke box that everyone could use rather than for each family to build its own. Additionally, some money may be saved if people purchased supplies and materials in large quantities as a group instead of buying smaller quantities as individuals.

IV. CHOOSING THE PRESERVATION METHOD RIGHT FOR YOU

Because of the vast variety of fruits and vegetables grown in any one locality, 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 developed 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 systems to use. The brief discussion following each question points out many factors that must be considered before a decision can be reached.

o 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.

o 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 the space available in the freezer, canning, drying, or curing may be better choices.

o 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.

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

o Is a special or unique taste treat desired? If so, then either canning or pickling may be the best choice, since both are used to make specialty foods.

o 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.

o 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.

o 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.

o 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)

National Drying Machinery Co.
2705 N. Hancock Street
Philadelphia, Pennsylvania 19133 USA
(Food Dryers)

Proctor & Schwartz, Inc.
251 Gilbralter Road
Horshan, Pennsylvania 19044 USA
(Food Dryers)

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