

# **Agrodok 3**

## **Preservation of fruit and vegetables**

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# Foreword

This Agrodok is meant to be a practical manual giving a review of the simple techniques used to preserve fruits and vegetables.

In addition to information provided in the previous edition of this Agrodok, this fourth edition covers more theoretical information on food decay in general, its causes and dangerous effects, as well as preventive measures that can be taken. In our opinion this knowledge is necessary if you want to start a small-scale preserving business, to which a whole chapter is devoted in this edition.

The general introduction deals with the principles of spoilage prevention. The various methods of preserving are then explained, and the main points of spoilage specific to the method are covered. The next chapters deal with jam and juice making and attention is paid to drying vegetables and fruit, as well as salting of vegetables. Freezing is not discussed, since this technique needs facilities usually not available in many developing countries. We have tried to describe every method as practically as possible, including descriptions of the required materials and techniques.

Finally we would like to thank some people for their contributions to the realization of this Agrodok: Domien Bruinsma for writing chapter 8 and critically reading the different concepts, Jan Schreurs for text editing, Mamadi Jabbi for making some new illustrations and Willem Würdemann for critically reading the content of this Agrodok.

Ife Fitz James

Bas Kuipers

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# 1 Introduction

All living creatures, including humans, depend on nature for their food. Humans are not only hunters and gatherers, but also farmers. We live from hunting and fishing, agriculture and animal husbandry. Most of our food consists of agricultural products, which are usually seasonal and spoil quickly. To make food available throughout the year, humans have developed methods to prolong the storage life of products: to *preserve* them. The rotting process can be postponed by adding preservatives, optimizing storage conditions, or applying modern techniques. The last option will not be discussed in this Agrodok. This booklet focuses on the traditional preservation methods still commonly used in developing countries for fruits and vegetables.

Fruits and vegetables provide an abundant and inexpensive source of energy, body-building nutrients, vitamins and minerals. Their nutritional value is highest when they are fresh, but it is not always possible to consume them immediately. During the harvest season, fresh produce is available in abundance, but at other times it is scarce. Moreover, most fruits and vegetables are only edible for a very short time, unless they are promptly and properly preserved.

This Agrodok will focus on a few simple and relatively inexpensive preservation techniques that can be applied on a small scale by an individual or a small group (of families for example). Chapter 2 provides information on food spoilage in general, its causes and dangerous effects, as well as measures that can be taken to prevent it. Specific knowledge is needed to apply the right preservation methods. Fruits and vegetables have to be specially prepared, for example, before they can be preserved. How this is done is explained in Chapter 3. Chapters 4 to 7 describe the various preservation methods: heating, drying, and the use of additives such as salt and sugar. In times of scarcity, preserved food can be sold for a good price. It can even be worthwhile to start a small preserving business. Chapter 8 explains what this would involve. More information can be found through the

addresses and literature listed in Chapter 9 and in the appendixes that follow, which provide specific information on how to prepare and preserve the various types of fruits and vegetables. Various terms that may be new to readers are defined in the glossary at the end of the booklet.

Agromisa welcomes all readers' comments that could contribute to improving the quality of our publications. A survey form is therefore included in the middle of this booklet, which can be completed and returned to us. Readers seeking more information on food preservation are also encouraged to contact Agromisa's Question and Answer Service at the address listed in the back of this booklet.

# 2 Food spoilage: causes, effects and prevention

## 2.1 What is food spoilage?

Every change in food that causes it to lose its desired quality and eventually become inedible is called food spoilage or rotting. As noted earlier, this Agrodok focuses specifically on fruits and vegetables. As long as they are not harvested, their quality remains relatively stable – if they are not damaged by disease or eaten by insects or other animals. However, the harvest cannot be postponed indefinitely: when the time is right, it is time to act. As soon as the fruits and vegetables are cut off from their natural nutrient supply, their quality begins to diminish. This is due to a natural process that starts as soon as the biological cycle is broken by harvesting. Once it is harvested, the agricultural product is edible for only a limited time, which can vary from a few days to weeks. The product then begins to spoil or ‘rot’. We distinguish between various types of spoilage:

- 1 physical spoilage
- 2 physiological aging
- 3 spoilage due to insects or rodents
- 4 mechanical damage
- 5 chemical and enzyme spoilage
- 6 microbial spoilage

Physical spoilage is caused for example by dehydration. Physiological aging occurs as soon as the biological cycle is broken through harvesting. Neither process can be prevented, but they can be delayed by storing the agricultural products in a dry and draft-free area at as low a temperature as possible.

Insects and rodents can cause a lot of damage. Not only by eating the products, but also by passing on micro-organisms through their hair

and droppings. The affected parts of the plants are then especially susceptible to diseases.

Chemical and enzyme spoilage occurs especially when vegetables and fruit are damaged by falling or breaking. Such damage can release enzymes that trigger chemical reactions. Tomatoes become soft, for example, and apples and other types of fruit turn brown. The fruit can also become rancid. The same processes can also be triggered by insects: the fruit becomes damaged, which causes enzymes to be released. Enzymes can be deactivated by heating the fruit or vegetables. The same effect can be achieved by making the fruit or vegetables sour or by drying them, but the enzymes become active again as soon as the acidity is reduced or water is added.

The peel of a fruit or vegetable provides natural protection against micro-organisms. As soon as this shield is damaged by falling, crushing, cutting, peeling or cooking, the chance of spoilage increases considerably. Crushing occurs most often when fruits or vegetables are piled up too high.

To prevent harvested products from spoiling, they can be preserved: physiological aging and enzyme changes are then stopped and micro-organisms are prevented from multiplying on the product. To retain the desired quality of a product longer than if it were simply stored after harvesting, it must be preserved. To preserve food it must first be treated, with the goal of stopping physiological aging and enzyme changes and preventing the growth of micro-organisms.

Before discussing the specific treatment methods, we will first focus on the subject of micro-organisms. What are micro-organisms? Why are they dangerous? How can you prevent them from making you sick? The answers to these questions will help you understand the steps required to safely preserve food.

## 2.2 What are micro-organisms, and what factors affect their growth?

Micro-organisms are very small, one-celled animals. There are three types: bacteria, moulds and yeasts. Bacteria and yeasts cannot be seen with the naked eye, but moulds are often visible because they form visible thin threads (filaments) or a solid cluster. Just like humans, micro-organisms require certain minimum living conditions. They cannot survive without:

- sufficient water
- oxygen
- the right degree of acidity
- nutrients
- the right temperature

**Water** is necessary for maintaining many physical processes. Where there is a shortage or lack of water micro-organisms cannot grow, such as in dried legumes. Drying is therefore one way to prevent spoilage. Meat and fish do not have to be 100% dry in order to preserve them. By adding salt, the remaining water becomes unsuitable for micro-organisms. The same effect can be achieved by adding sugar to fruit. Enzymatic spoilage is also inhibited by drying.

Most micro-organisms need **oxygen**. If there is a shortage of oxygen, it is difficult for bacteria to survive, let alone multiply. But there are always a few that manage to survive. As soon as the oxygen supply is increased, these remaining bacteria will again grow and multiply. Some types of micro-organisms even thrive in an oxygen-poor environment.

Bacteria grow best in an environment that is not too **acidic**. Less acidic products are therefore especially susceptible to bacterial spoilage. Examples of such products are meat, eggs, milk and various types of vegetables. Beer, yoghurt, wine, vinegar and fruit are less sensitive because they are more acidic. Adding acidity to products slows down the process of microbial spoilage. The degree of acidity is measured as a pH level. A neutral product like milk has a pH of 7; meat has a pH of

about 6, carrots have a pH of 5 and oranges about 4. The more acidic a product is, the lower the pH value will be.

Just like humans, micro-organisms also need **nutrients**: sugars, proteins, fats, minerals and vitamins. These are rarely in short supply, because they can be found in all food products.

To thrive, micro-organisms need a **temperature** of between 5 and 65°C. At temperatures above 65°C it becomes very difficult for them to survive; and they definitely die if boiled, as long as they are boiled for a certain length of time, such as 10 minutes. When heated, the micro-organisms slowly die off, but not all at the same time. Heating at temperatures lower than 100°C thus has to be sustained for a longer period. The growth of micro-organisms is also slowed down significantly at temperatures between 0 and 5°C (as in a refrigerator), which makes it possible to store the food products for a few additional days. At temperatures below 0°C microbial growth is stopped completely, but the micro-organisms themselves remain alive. They will become active again as soon as the temperature rises above 0°C.

To preserve food, it is sometimes necessary to make drastic changes to the micro-organisms' living conditions. We can remove water (drying), increase the acidity, or first heat the products (to kill the bacteria) and then store them in air-tight containers to prevent oxygen from entering (preserving/canning). These and other methods will be discussed later in this booklet.

### **Do micro-organisms grow differently on vegetables and fruit?**

Vegetables and fruit have a lot in common. But there are also important differences, which determine the type of spoilage they are most susceptible to. Damaged fruits, which are usually somewhat acidic, are very susceptible to the growth of yeasts and moulds. Vegetables are generally less acidic, and their spoilage is usually caused by bacteria. Though not visible to the naked eye, bacteria can still be present in large numbers.

## **What types of micro-organisms grow on what products?**

- *Moulds* can be found on almost all food products. They are often very visible and can significantly alter the taste of the products. They grow the best in low temperatures in an acidic environment and on dry products such as grains and bread. Some moulds produce poisonous substances, especially in moist seeds such as peanuts, corn and soy beans.
- *Yeasts* can also cause food to spoil. They prefer low temperatures and acidic products.
- *Bacteria* can grow on almost all types of fresh food that is not too acidic: meat, fish, milk and vegetables. One type of bacteria carries a kind of seed, called a spore. Spores can survive at a temperature of 100°C, even though the bacteria themselves die. Once the temperature drops, new bacteria can grow out of the spores. To kill the spores, they must be exposed to a temperature of 121°C. This is called sterilization.

## **2.3 What do micro-organisms do to fruits and vegetables?**

Micro-organisms take from food products the various substances they need to survive and multiply. Their secreted waste products can have either a negative or positive effect on the affected food and the humans who eat it.

### **Positive effects of micro-organisms in food**

The waste products secreted by some micro-organisms can have a positive effect on food. Lactic acid bacteria, for example, are used to make cheese and yoghurt from milk, and sauerkraut from white cabbage. Moulds are used to make tempeh from soy beans, and yeasts are used to make beer and bread. These substances influence the taste and structure of the food products and generally increase their shelf-life. The products can be kept longer because the desired micro-organisms decrease the food's pH level or because they are present in such huge numbers that other micro-organisms have no chance to grow. This use

of micro-organisms for the preparation of food is called *fermentation*. More information on this process is given in Chapter 6.

### **Negative effects of micro-organisms in food**

Sometimes the negative effects of bacteria are clearly apparent, such as when milk has turned sour and curdled, when meat is covered in slime, when moulds and gasses have formed, and when food has a distinctly putrid smell. However, food spoilage is not always this obvious. There are bacteria whose presence in food does not always cause a change in its taste or appearance. In any case, it is important to avoid eating rotten food, because it can make a person seriously ill.

Eating rotten food can cause contamination or poisoning. A *food contamination* occurs when a person consumes a large number of living micro-organisms in a meal. These can multiply rapidly in the person's gastrointestinal tract and severely disturb the digestive system. The result is often diarrhoea and sometimes also bleeding. The symptoms appear between 3 and 24 hours after eating the rotten food. A food contamination can be prevented by frying or boiling the food thoroughly, since sufficient heating will kill the micro-organisms.

*Food poisoning* occurs when a person consumes food containing the poisonous waste products secreted by the bacteria. Heating the food does not help in this case: the bacteria will be killed, but the poisonous waste will remain unharmed. Both food poisoning and food contaminations can be *lethal*, but usually they only make a person sick.

### **How do micro-organisms come in contact with fruits and vegetables?**

Spoilage caused by yeasts, moulds and bacteria develops slowly and is not always noticeable. The most important sources of microbial contaminations are sand, water, air, and pests such as insects and rodents. Food products can also be infected by people. Micro-organisms are everywhere around us. To prevent them from reaching our food in great numbers, it is important to work as hygienically as possible when handling fruits and vegetables, for example.

The following practices are therefore recommended:

- Wash your hands thoroughly with hot water and soap before beginning to prepare food.
- Make sure that kitchen utensils and appliances are well cleaned and disinfected.
- Always store food in a clean place.
- Use herbs and spices as little as possible, because they are an important source of contamination.
- Use clean and pure salt only – if the salt is not pure, heat it on a dry, metal sheet above the fire.
- Allow only clean drinking water to come in contact with fruits and vegetables.
- Never allow anyone who is sick or has open wounds to come in contact with food that is to be preserved.

## 3 Preparation

Fruits and vegetables should be prepared for preservation as soon as possible after harvesting, in any case within 4 to 48 hours. The likelihood of spoilage increases rapidly as time passes. This chapter discusses preparation methods used for the various preservation methods discussed in Chapters 4 to 7.

### 3.1 Cleaning and washing

First, the fruits or vegetables have to be thoroughly cleaned to remove any dirt or insecticide residues. The outer layers of onions also have to be removed. This cleaning process usually involves washing the products under a faucet with running drinking-water or in a bucket with clean water that is regularly refreshed. When cleaning leafy vegetables, it is best to first remove the stems. Some types of fruit, such as cherries, strawberries and mushrooms are *not* washed, because this would actually increase the spread of micro-organisms. It is also not advisable to wash cucumbers, because this shortens their shelf-life.

Dried beans and nuts are soaked in water for 16-20 hours before being processed further. To prevent the beans and nuts from turning black, a stainless steel pan or bowl, or other galvanized material, should be used. The temperature of the soaking water should remain constant.

### 3.2 Lye dip

Some products, such as plums and grapes, are immersed for 5-15 seconds in a pan of hot, almost boiling, lye (NaOH; 10-20g lye/litre water) to make the peel rough and to thereby speed up the general drying process. The peel then also separates more readily from the fruit, which makes it easier to remove. After such a treatment, the fruit has to be rinsed vigorously with cold water to remove the lye residues. Lemon juice can also be used to neutralize any remaining lye residues.

The preparation method described above is considered to be ecologically harmful because alkaline is transported by the waste water into the environment. Other disadvantages of using lye are that the food can become discoloured and the metal pan could become corroded. The use of too-high concentrations of lye is also unhealthy for the people working with it.

### **3.3 Sorting**

To achieve a uniformly sized product, fruits and vegetables are sorted immediately after cleaning according to their size, shape, weight or colour. Sorting by size is especially important if the products are to be dried or heated, because their size will determine how much time will be needed for these processes.

### **3.4 Peeling**

Many types of fruits and vegetables have to be peeled in order to be preserved. This can easily be done with a *stainless steel* knife. It is extremely important that the knife be made of stainless steel because this will prevent the discolouration of the plant tissues. It is best to first submerge citrus fruits, tomatoes and peaches, whose peels are all securely connected to the fruit, in hot water for 1 ½ to 3 minutes. The softened peel can then be removed without too much effort.

### **3.5 Cutting**

Cutting is important because you will need approximately uniform pieces for the heating, drying and packing stages. Fruits and vegetables are usually cut into cubes, thin slices, rings or shreds. The cutting utensils have to be sharp and clean to prevent micro-organisms from entering the food. From the moment they are cut, the quality of the products decreases due to the release of enzymes and nutrients for micro-organisms. A decrease in quality is also caused by the damage done to the plant tissues. For this reason, the interval between peeling/cutting and preserving has to be as short as possible.

## 3.6 Blanching

Blanching or ‘pre-cooking’ is done by immersing fruits or vegetables in water at a temperature of 90-95°C. Exposing them to steam is also possible. The result is that fruits and vegetables become somewhat soft and the enzymes are inactivated. Leafy vegetables shrink in this process and some of the micro-organisms die. Blanching is done before a product is dried (see Chapter 5) in order to prevent unwanted colour and odour changes and an excessive loss of vitamins. Fruit that does not change colour generally does not need to be blanched. Onions and leek are not at all suited for blanching.

Blanching is quite simple. The only thing you need is a large pan with a lid and a metal, or in any case heat-resistant, colander (see Figure 1). Place the fruit or vegetable in the colander (a linen cloth with a cord will also do) and immerse this in a pan with sufficient nearly boiling water to cover the food completely. Leave the colander in the pan for a few minutes and turn the food occasionally to make sure that it is heated evenly. Immediately after the colander is removed from the pan the food has to be rinsed with cold, clean running water. Make sure that the extra water can run off. If no faucet is available, a container with drinking-water can also be used, as long as the water is cold and clean. During the blanching process, it is important to monitor the time and the water temperature (Appendix 4 gives an overview of recommended blanching times per vegetable).

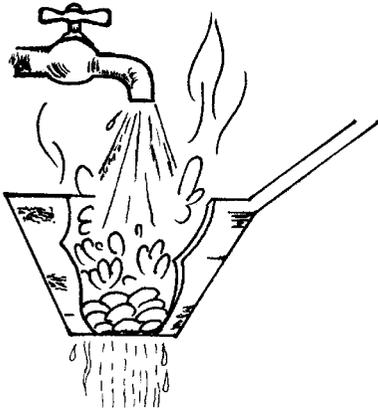
The disadvantage of this blanching method is that many vitamins are lost in the hot water. Steaming is therefore a better alternative. Only a small amount of water has to be added to the pan and brought to the boil. Make sure that the fruit or vegetable in the colander is touched by the steam but not by the water. This blanching method is similar to the method for extracting juice described in Figure 12 and Chapter 7.



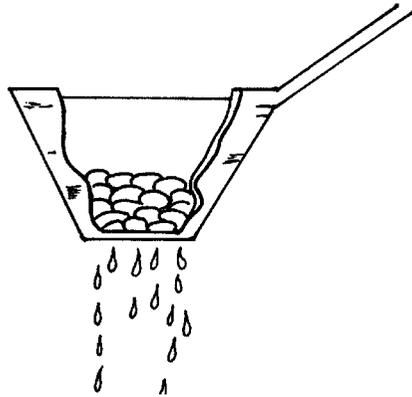
a. Pan of hot water



b. Product in colander is completely immersed in water



c. Rinsing and cooling under running water



d. Drip drying

**Figure 1: Blanching**

## 4 Preserving by heating

### 4.1 Introduction

One of the most common and effective ways to preserve fruits and vegetables is to prepare them and place them in air-tight containers, which are then heated. The high temperatures ensure that micro-organisms are killed and the enzymes are inactivated. Any remaining spores will not have the right conditions to grow into bacteria and microbial contamination from outside is prevented. However, it is important to remember that some micro-organisms are unfortunately less sensitive to heat: *Clostridium* and *Staphylococcus* can still multiply and spoil the food through the poisonous substances they produce. *Clostridium* can cause botulism and result in tragic deaths. This bacteria does not thrive as well in more acidic products such as fruit (pH < 4.5).

The heating method for fruit is different than for most vegetables. As noted above, fruit has a low pH level. It can be heated in boiling water (100°C), whereas most vegetables have to be heated at temperatures above 100°C, because they have a higher pH and are thus more susceptible to bacterial contamination.

This preservation method produces the best results, but only if fresh products are used and the instructions for heating are followed exactly. As with other methods, heating has advantages and disadvantages as outlined below.

#### **Advantages**

- Most micro-organisms are destroyed so there is less chance of spoilage.
- After being sterilized and stored, the food can be kept longer and more safely.

#### **Disadvantages**

- Heating requires the following investments:

- Heat-resistant storage containers (which can be difficult to obtain) such as cans or glass jars. The latter are preferred because they can be reused.
  - Cooking utensils, such as a steamer
  - Fuel
- These investment costs will have to be represented in the final cost of the product.
  - This method is labour intensive.
  - It requires access to abundant clean water.
  - Preserved fruits and vegetables have a lower nutritional value and generally less taste than fresh products. However, fewer nutrients are lost using the heating method than any other preservation method.

Pasteurization and sterilization are two methods of heating food products to prevent them from rotting and to prepare them for storage in glass jars or tins. These methods will be explained later in this chapter, but first we will discuss the packing and preparation of vegetables.

## 4.2 Packing

Even though increasing the container volume decreases the cost per kilogram of packing a product, there are two reasons to avoid using large containers. First, the entire content of the container has to be consumed within 24 hours after opening it; and second, it will take much longer before the food in the middle of the container is heated sufficiently to kill all the bacteria. Heating the product longer will increase the energy costs. If large volumes are desired, it is best to work with flat tin containers, since the distance from the nearest edge of the container to the centre is smaller and the product will therefore heat up quicker.

Of course the packing material must be clean. The more micro-organisms that come in contact with the food, the longer the heating process will have to take. The two types of containers used to preserve food with the heating method (tins and glass) are described below.

## **Tins**

These are iron cans, which are covered with a thin layer of tin. They are especially used for sterilizing, and are very suitable for sterilizing larger amounts. Unfortunately, they can only be used once. There are many different types available with varying volumes and shapes (cylindrical tins are long, round and narrow, while flat tins are wide and shallow). A few common volumes are: 0.58 l / 0.85 l / 0.95 l / 3.1 l.

Tins can also vary with respect to the presence or absence of a varnish layer on the inside. Unvarnished tins are often good enough. However, varnished tins must be used for special products, such as cherries, berries and plums, in order to maintain good colour and taste. In these and other products, tin triggers chemical reactions that change the product's colour and/or taste. Varnish thus avoids contact between the tin and the product.

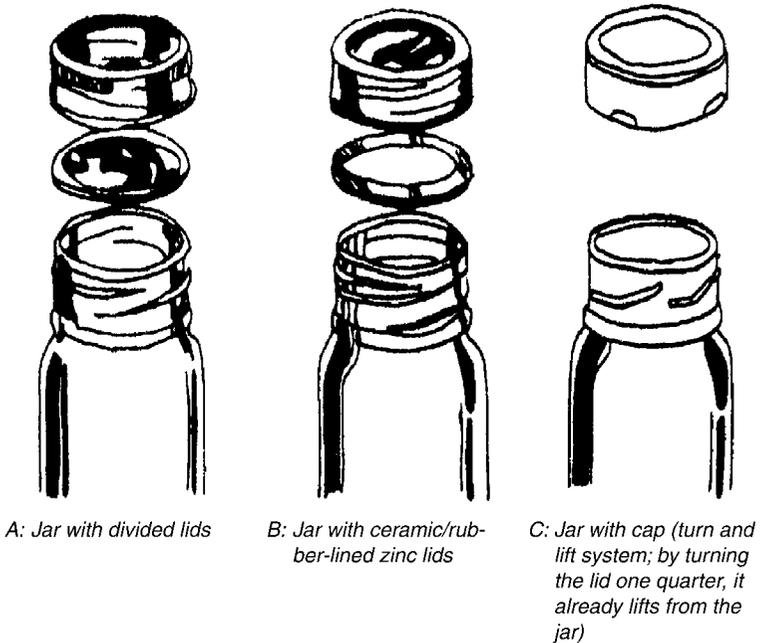
Every tin comes with a lid, which can be hermetically sealed with the help of a tin sealer. Various types are available, ranging from simple hand-operated tools to new automatic machines. The seal must be properly adjusted to prevent leakage. This can be checked by closing the tin with a little water inside and immersing it in boiling water. If, after a few minutes, steam is seen to escape, the seal must be re-adjusted.

Tins delivered from the factory are fairly clean, and do not require extra washing. Store them upside down to keep out contaminants. If they are not clean, wash them in hot soda water (1.5%), rinse with hot water and let them drip dry on a clean cloth. The lids must also be clean.

## **Glass**

Glass bottles and jars can be used for sterilization and pasteurization and they are normally reusable. However, they are also breakable and they do not protect food from the negative effects of light. This problem can be alleviated by storing the filled bottles and jars in a dark place.

Glass bottles, those previously used for soft drinks or beer for example, are well suited for heating and storing fruit pulp, puree or juice. They have to be sealed with a metal screw cap. Their volume can vary from 0.2 to even 2 litres. These bottles and their screw caps can easily be reused.



*Figure 2: Glass jars with different sealing mechanisms*

It is important that the bottles or jars be completely hermetically sealed. This can be done by inserting a soft layer of rubber or other similar material between the bottle or jar and the cap or lid. This rubber layer can be separate or attached to the cap as shown in Figure 2. Producers of glass bottles and jars often also sell accompanying rubber rings and lids or caps. The best results are achieved when the glass containers and sealing mechanisms (rings, caps and lids) are made by the same company.

The bottles or jars and their caps or lids must first be thoroughly cleaned with soda (15 gram/litre) and hot water. Allow them to soak in the hot water until the moment they are used.

### **4.3 Preparation**

Before a product is heated in its storage container, it must be prepared as explained in Chapter 3. Read that chapter again before proceeding, because the preparation step is very important for the success of the entire preserving process. Specific information about the appropriate ways to prepare and preserve the various types of fruits and vegetables can be found in Appendixes 1,2 and 3:

- 1 Pasteurization (heating up to 100°C) – for products that will be subsequently stored at temperatures below 20°C (Section 4.4.1 and Appendix 1);
- 2 Sterilization at 100°C – only for acidic products (Section 4.4.2 and Appendix 2);
- 3 Sterilization (above 100°C) in a pressure cooker or an autoclave (large pressure cooker) (Section 4.4.3 and Appendix 3).

Each appendix consists of two tables. The first table lists the recommended preparation method for each product and the content of the fluid with which the fruit or vegetable is preserved. The second table lists the temperature at which the glass container or tin should be filled and the recommended duration of heating for various sizes of glass and tins. The food to be preserved is usually heated in a large pan and then packed while still hot, before the actual heating process even begins. This is the most efficient method, because it is faster to thoroughly heat a large amount of food in a large pan by continually stirring it than to heat smaller amounts of food in individual sealed bottles or tins. It takes much more time for the heat to penetrate to the centre of the food in the jars.

## 4.4 Three types of heating

The previous section mentioned three types of heating (1, 2 and 3 above). Before discussing each of these in detail, we will give an example of how tins, jars and bottles should be filled. The products are first prepared as described in the appendixes. The following example demonstrates how these appendixes should be used:

To preserve white beans in 0.85 litre tins:

First peel and wash the beans and then blanch them for 3 minutes (see Chapter 3). Large beans should first be soaked in water overnight. After blanching and straining the beans, put them in the cans, which are then filled almost to the brim with boiling, salted (2%) water (see Appendix 3a). Seal the cans while the content is at a temperature of at least 60°C. Place the cans in a pressure cooker and heat them for 85 minutes at a temperature of 115°C (see Appendix 3b).

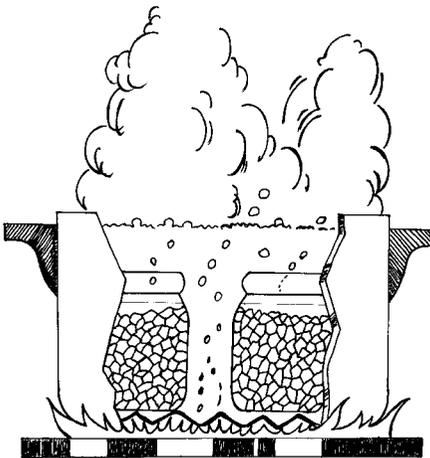
The tins or jars have to be filled up to 0.5 cm below the *sealing edge*. For leafy greens the fluid has to be poured into the tin or glass container first, followed by the vegetable. Make sure to eliminate as many air bubbles as possible. The *sealing temperature* is very important. It may never be lower than indicated in the appendix. If the temperature of the food is lower, the jars and tins must be quickly reheated in a shallow water bath until the temperature of the food in the middle of the tin is equal to or higher than the indicated temperature. Always measure the temperature in the middle of the tin. Seal quickly and apply the recommended heat treatment. Put the filled bottles or jars in the water before it boils to prevent the glass from breaking due to the sudden increase in temperature. Tins can be placed immediately in boiling water.

Important: If a sugar solution of 40% has to be used, this is not 400 grams of sugar with 1000 ml (1 l) water, but 400 grams of sugar in 600 ml water.

## Pasteurization

Pasteurization is a mild heating treatment at temperatures up to 100°C (which is the boiling point of water at elevations up to 300 metres above sea level). This method causes only a slight decrease in taste and nutritional value. The enzymes are inactivated and most, but not all, bacteria are killed. Pasteurized products therefore spoil faster than sterilized products. To prevent the surviving spore-producing micro-organisms from multiplying, the products should be stored in temperatures below 20°C. To extend the shelf-life of fruit preserves, a lot of sugar is often added, which allows them to remain edible for months. Chapter 7 gives more information on preserving fruit with sugar. The more acid or sugar contained in a pasteurized product, the longer it will stay good because the remaining micro-organisms do not have a chance to develop.

A product is pasteurized by heating it for a time in a closed glass or tin container in a pan of hot water (see Figure 3). It is important that the lid of a glass jar fit well, but it should not be twisted tightly closed, because some air should be allowed to escape while it is being heated. Close the lid tightly immediately after removing the jar from the pan. As the product cools, a vacuum will develop within the container. In this way the food has no chance of coming in contact with the air and becoming contaminated.



*Figure 3: Jars in a pan*

The water in the pan has to be warm and at least the same temperature as the filled bottles and tins. Start monitoring the heating time as soon as the water has reached the recommended temperature listed in the appendix. Remove the bottles or tins as soon as the recommended time has elapsed and allow them to cool.

Remember that the boiling point of water decreases as elevation increases. In areas up to 300 metres above sea level the boiling point is 100°C. At higher elevations the heating time will have to be increased as indicated in the following table in order to compensate for the lower boiling temperatures.

*Table 1: Heating time at different altitudes*

Altitude in metres	Heating time in minutes	Example
0 - 300	a	a = 10 minutes
300 - 600	a + 1/5 a	total 12 minutes
600 - 900	a + 2/5 a	total 14 minutes
900 - 1200	a + 3/5 a	total 16 minutes

Since pasteurization sometimes requires heating at 100°C and the food can be kept for only a limited time, it is better not to pasteurize food (as described in App. 1) at elevations higher than 300 m, but rather to sterilize it (possibly under pressure) as explained in App. 3. Products that have to be heated at temperatures below 100°C can be made at higher elevations, as long as the required temperature can be achieved.

Fruit juices, which are not listed in the appendixes, have to be pasteurized at temperatures between 60 and 95°C. More information on fruit juices can be found in Chapter 7.

Always cook the preserved vegetables for 15 minutes before eating them. Never eat spoiled food and never eat from jars that have opened during storage.

### **Sterilization in a bath of boiling water**

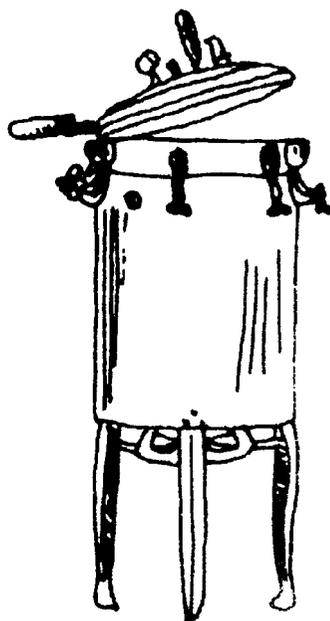
Sterilization in a boiling water bath is performed at 100°C. This process will kill all the micro-organisms present, but not the spores they produced. Under the right conditions, these spores can grow into spoilage-causing bacteria. Since the spores do not grow well in acidic conditions, acid is often added to the preserved food. Sugar has the same preventative effect. Thus by adding sugar or acid, you can en-

sure that even after heating at just 100°C the preserved product can be considered to be sterilized: its shelf-life is much longer than a product heated at 100°C to which no extra acid or sugar has been added. Appendix 2 provides the information you will need to sufficiently sterilize various types of fruits and vegetables.

### **Sterilization with a pressure cooker or autoclave**

Sterilization carried out properly in an autoclave or pressure cooker (see Figure 4) will kill not only the micro-organisms but also the spores. In this way a long shelf-life can be achieved without adding extra acid or sugar.

In an *autoclave* or pressure cooker the boiling point of water is at a temperature higher than 100°C. If the atmospheric pressure (at sea level) is increased by 0.7 bar, then the water in this pan will boil at 115°C; if the pressure is increased by 1 bar the boiling point becomes 121°C. Here too, the boiling temperature is lower the higher above sea level you are. This decrease can be compensated by increasing the pressure by 0.1 bar for every 1000 metres above sea level. To sterilize canned vegetables the temperature is allowed to reach 115-121°C. In general, all foods with a high pH (which includes most vegetables) have to be preserved at a temperature above 100°C. We recommend that a pressure cooker be purchased for this purpose. Appendix 4 provides temperature and time combinations needed to sterilize foods in a pressure cooker or autoclave.



*Figure 4: Autoclave*

The following instructions generally apply when sterilizing foods:

- Place a rack on the bottom of the pan to ensure that the jars/bottles/tins do not come in too close contact with the heat source.
- Remember not to place the filled glass jars or bottles directly in boiling water, because they will most likely break. Heat the water in the pan up to about the same temperature as the filled jars or bottles, and then place them in the water.
- Do not screw the lids on too tightly, to ensure that some air will be able to escape (see Section 4.4.1 or Section 6.1.2).
- Do not pack the jars or bottles too tightly in the pan. Leave some space between them and between the jars/ bottles and the sides of the pan.
- The jars or bottles should be covered by at least 5 cm of water.
- The sterilization time begins at the moment the water reaches the desired temperature.
- For optimal results use jars of the same size and volume.
- Never try to open the *autoclave* or pressure cooker while the water is boiling. The high pressure in the pan and the high temperature of the water make this very dangerous!

Remember the following points when sterilizing under high pressure using tins or glass.

### *Tins*

After the processing, let the steam escape from the pan slowly. This can be done quicker with small tins than with bigger ones, but still should be done slowly and carefully, as the tins can deform or even burst. When the pressure is again normal the lid of the pan can be opened. Remove the tins and immerse them in cold water, which should be refreshed occasionally to keep it cold. When the tins are cool dry them.

### *Glass jars*

Wait until the pressure cooker cools down and the pressure inside of it has gone down before opening the lid. Remove the jars and tighten the

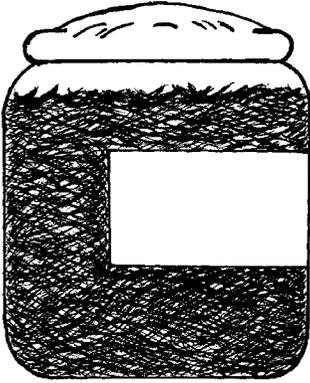
lids immediately. The disadvantage of glass jars is that they cannot be cooled quickly. The safest way to cool them is to set them in the open air until they are lukewarm, and then put them in cold water.

The advantage of an *autoclave* over a pressure cooker is that it can be cooled down faster. On the other hand, an *autoclave* requires more water and thus more energy to heat.

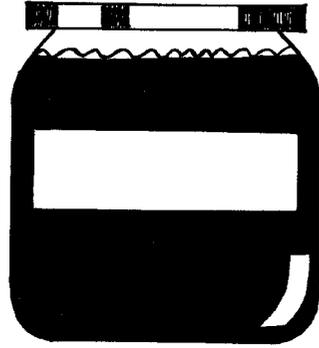
## **4.5 Storage and consumption**

Always store the preserved food in a cool place, at a temperature preferably below 20°C. Keep glass bottles and jars out of the light. Label the containers so that you know what they contain and the date they were preserved. Always consume the older products first. The storage area has to be dry and have a consistent temperature. Moisture will make tins rust. Pay close attention when opening preserved food. A bulging lid or tin indicates gas formation by bacteria and thus food spoilage. Look carefully at the food and smell it. Heat the food if necessary and never eat anything you suspect may be spoilt.

Remember that preserving vegetables and fruit is always a risky undertaking. Always follow the rules described in this booklet and keep in mind that the heating times given in the appendixes represent the minimum time that is required. Never heat products for a shorter time than indicated. Heating food for a longer time decreases the chance of spoilage, but it also decreases the food's taste and nutritional value.



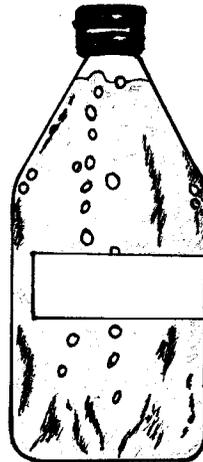
*a. Bulging lid due to gas formation*



*b. Formation of slime coating on product*



*c. Mould growth*



*d. Formation of gas bubbles*

*Figure 5: Examples of products that are spoilt*

## 5 Drying

*Drying* is one of the oldest preservation methods. The moisture level of agricultural products is decreased to 10-15% so that the microorganisms present cannot thrive and the enzymes become inactive. Further dehydration is usually not desired, because the products then often become brittle. To ensure that the products do not spoil after being dried, they have to be stored in a moisture-free environment.

Drying is generally not difficult. Since the products lose water, they also become much lighter and thus easier to transport. Two disadvantages, however, are that the products also lose vitamins, and they change in appearance.

This chapter describes how vegetables and fruits are dried. More information on drying beans, grains and other products can be found in Agrodok 31: *The Storage of Tropical Agricultural Products*.

The most common drying method is exposure to air. Air can absorb water; and the warmer the air is, the more it will absorb. For optimal results, the air should be hot, dry and in motion. In a closed environment, the air has to be refreshed regularly because it will otherwise become saturated with the moisture it absorbs from the products. Good ventilation is therefore essential. For drying, the relative humidity (RH) of the air should be less than 65%. If the RH is higher than 65% the fruits and vegetables will eventually dry out, but not in the right way. When the sun is shining, the RH is usually lower than 65%, but when it is cloudy and definitely when it is raining the humidity is usually higher. Sunshine is therefore extremely important! For this reason, it is not possible to dry products in this way in every season of the year.

Before drying, the vegetables and fruits have to be thoroughly washed and cut into pieces if necessary. Sometimes extra preparation is needed to retain the product's colour and to minimize nutrient loss.

The various preparation methods are described in Chapter 3, and a list of methods required for drying each agricultural product is given in Appendix 4.

The final quality of the dried product is determined by a large number of factors, which can be divided into four groups:

- 1 Quality of the product to be dried
- 2 The preparation of the product
- 3 The drying method used
- 4 The packing and storage conditions

These four points are discussed in the following sections, followed by examples of drying potatoes, tomatoes and mango.

## **5.1 Quality of the fresh product**

The fruits and vegetables to be dried should be of good quality. Fruit that is rotten or damaged in any way should be separated from the good fruit. To prevent the product from losing its quality, the time between harvesting and drying should be as short as possible. Of course it is possible to wait longer before drying hard fruits and root vegetables than before drying soft fruit and leafy vegetables. The time normally allowed between harvesting and consumption can also be seen as the maximum time allowable between harvesting and drying.

## **5.2 Preparation**

Before describing the various preparation methods used specifically for drying, we would like to remind the reader that the hygiene rules described in Chapter 2 must also be followed when drying food.

### **Washing and cutting**

Wash the fruits and vegetables thoroughly. Remove sand, rotten spots and seeds. Peeled and cut fruit dries quicker. It is important that all of the pieces are about the same size, so that they will dry at the same rate.

Tubers and roots should be cut into slices that are 3 - 6 mm long or pieces that are 4 - 8 mm thick. Leafy vegetables such as cabbage should be cut into pieces that are 3 - 6 mm thick.

### **Lye dip and blanching**

See Chapter 3.

### **Osmotic drying**

Some fruits can be prepared by immersing them for some time in a strong sugar solution. In fact this is not just a preparation, but already the start of the drying process because the sugar extracts water from the fruit. The fruit also adsorbs part of the sugar and is therefore allowed to retain more water at the end of drying process, which makes the product softer than if it were dried only in the air.

Normally sugar solutions of 40-60% are used. Good results are obtained by dipping the product for 18 hours in a 40% sugar solution. (An example of this is given in section 5.6.) To make such drying profitable it is necessary to have a good use for the diluted sugar solutions, such as the production of jams or syrups. More information about this treatment can be found in the FAO publication of G. Amoriggi (1998) (see "Further reading").

### **Preservatives**

Fruit is sometimes treated with the smoke from burning sulphur or dipped in a sulphite or bisulphite-salt solution to prevent browning. Taste and vitamin C content are also better preserved with these treatments. The residual sulphite in the product can, however, be dangerous in high concentrations and can also affect the taste.

As this method needs more specific information we cannot discuss it here in detail. If you would like to know more about this, please write to Agromisa at the address given on the back cover.

### 5.3 Drying methods

Drying in the open air is called *natural drying*. We speak of *artificial drying* when the air is first heated to decrease the relative humidity to a desired level. Both methods are described below.

#### Natural drying

Drying in the open air is a simple and inexpensive process. It does not require any costly energy, just sunlight and wind. The product to be dried is placed in thin layers on trays (see Figure 6) or black plastic and exposed to direct sunlight. The trays are usually made of wood, and lined with plastic or galvanized nets. The trays should be placed 1 metre above the ground on stands set on a flat surface. This way no dirt can come in contact with the food from below and the food can receive maximum sun exposure. If necessary, the trays can be covered to protect the food from rain, dust, birds, insects and other pests. Mosquito netting probably offers the best protection from pests. To ensure that the fruits or vegetables dry uniformly, it is best to turn them regularly or at least to shake the trays. This does not apply to tomatoes, peaches or apricots, which are cut in half and arranged in a single layer on the trays.

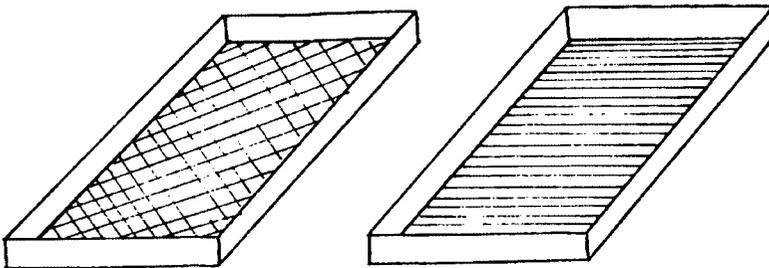


Figure 6: Drying tray

Fruit dries very well in the sun, but some products are damaged by exposure to direct sunlight and are therefore dried preferably in a

shady spot. Beans and (red) peppers, for example, are bunched and hung up under some type of shelter. Of course, drying these products takes more time.

In areas with a high chance of rain, it is advisable to have an artificial dryer that can be used when it is raining or when the RH is too high. This will prevent interruption in the drying process and thus also a loss of food quality. In the event of rain, the (moveable) trays should be covered with plastic or placed under a shelter. Afterwards, they should be returned as soon as possible to the drying spot. It takes about two to four days to dry tropical vegetables.

### **Artificial drying**

The temperature of outside air often needs to be increased only by a few degrees to make drying possible. For example, during a rain shower at 30°C the air must be heated to at least 37°C to be able to dry fruits or vegetables. Heating it further increases the speed at which the product will be dried because:

- the air can absorb more water
- the product releases water faster at higher temperatures.

The air can be heated with solar energy or by burning natural or fossil fuels. Appendix 4 gives information about preparation, drying conditions and maximum temperatures for several types of vegetables and fruit. The maximum drying temperature is important because above this temperature the quality of the dried product decreases quickly. Another reason for not drying at very high temperatures is that the product then dries quickly on the outside, but remains moist on the inside. Different types of artificial drying will be discussed below.

### *Improved sun drying*

Products dry quicker when the trays are placed in a structure that allows the sunlight to enter through a glass cover, thereby trapping the warmth. This raises the temperature to 60-75°C. Overheating can be avoided by regulating the ventilation (see Figure 7).

Without ventilation the temperature can reach 90-100°C, especially towards the end of the drying process. The ventilation must be good enough to prevent condensation on the glass. This is a direct drying method.

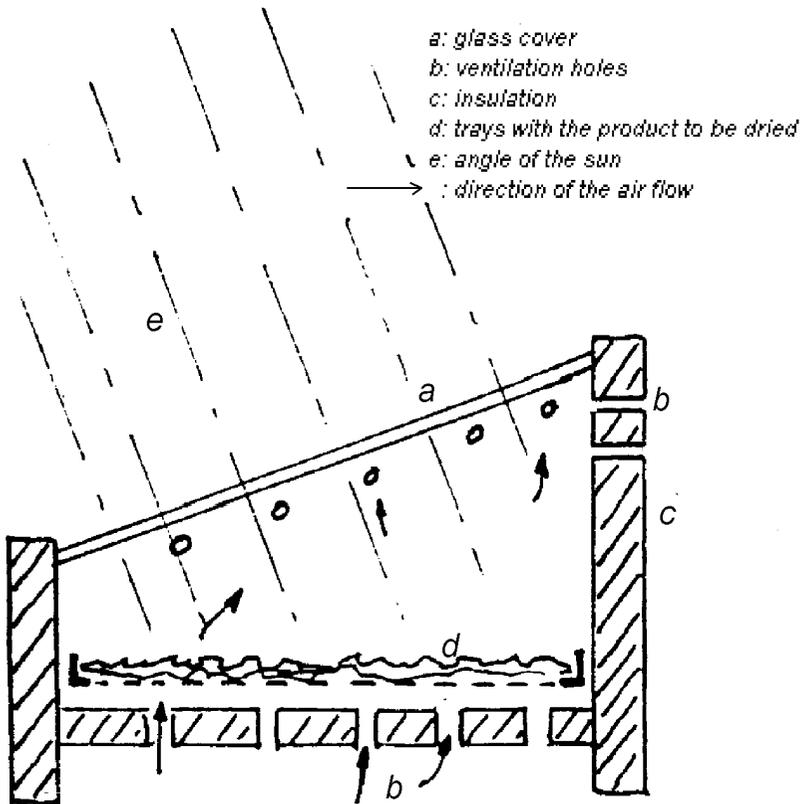


Figure 7: Improved direct sun dryer

It is also possible to heat the air in special boxes before leading it to the product (Figure 8). This method is called indirect drying, because there is no direct solar radiation on the product. These techniques will

speed up the sun drying in dry areas (beware of overheating), resulting in a better product.

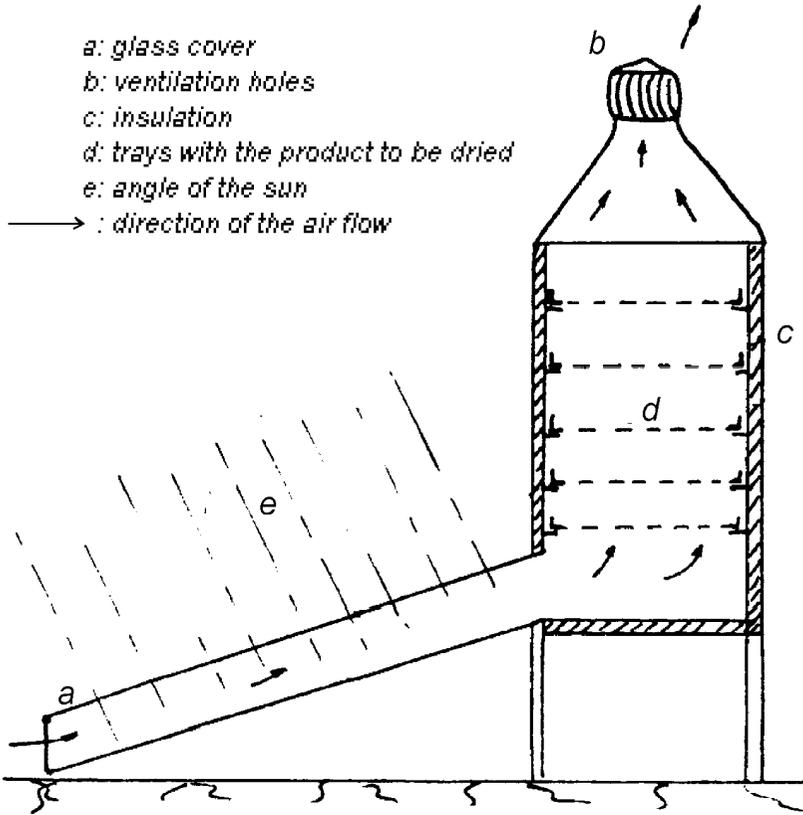


Figure 8: Improved indirect sun dryer

These techniques also make drying possible in areas with high humidity, as the relative moisture decreases with a higher temperature, as explained earlier in this chapter. An extra advantage of this technique is that the product is protected from rain. If you are interested in this method of drying, you can write to Agromisa to obtain specifications for building and using drying boxes.

### *Heating with fuel*

In wet climates, or when large quantities (over 100 kg/day) have to be processed, one should consider heating the air, if fuel is available. Vegetables dry better with this method than in the sun, and the colour, odour and taste of the end products are better. Two methods will be briefly described to give an idea of the technique.

### *The bush dryer*

A fire in an oven made from oil drums heats the surrounding air. The heated air rises through a thin layer of the product that is to be dried on the racks. The fire must be watched at all times, and the product has to be shaken or stirred at regular intervals. See Figure 9.

Specifications of the bush dryer:

capacity: 0.1 to 1 ton/day (24 hours)

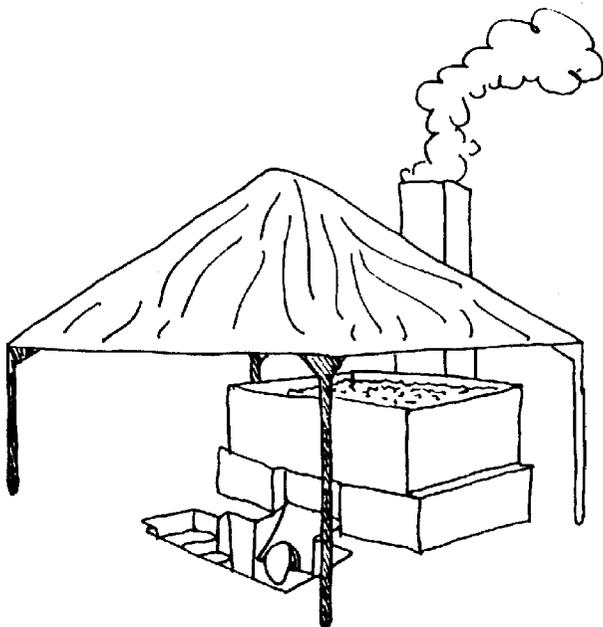
material: oil drums, galvanized iron sheets, netting, wire, wood, nails, one sack portland cement, sand, stones

costs: building costs, material costs, high fuel costs and attendance

construction: accurate work is required

### *Air dryers with artificial ventilation*

A motor-powered ventilator can be used to blow warm air from the motor (or air warmed by a burner) through the product. Please contact Agromisa for further information about building air dryers with artificial ventilation.



- a: oven
- b: cold air
- c: heated air
- d: product
- e: chimney

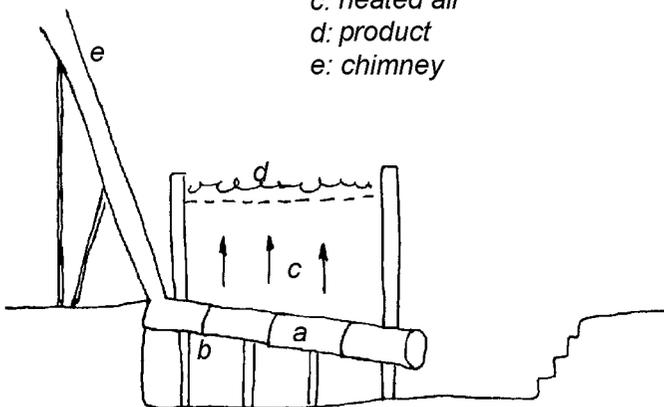


Figure 9: Bush dryer

## 5.4 When is the drying process finished?

To test whether a product is sufficiently dry, it first has to be cool. A warm product is softer and seems to contain more water. Fruit may contain 12-14% water; vegetables should be dryer, containing 4-8% water depending on the type, since vegetables contain less sugar. The moisture content is difficult to measure without a drying oven or moisture content meter. As rules of thumb use the following:

Fruit:

- It should not be possible to squeeze juice out.
- The fruit must not be so dry that it rattles when the drying trays are emptied.
- It should be possible to knead a handful of fruit pieces, but they should not stick to each other.

Vegetables

- Dried greens should be brittle and can be easily rubbed into a powder.

## 5.5 Packing and storage

At the end of the drying period all foreign material (stems, etc.) should be removed, as well as pieces that are not yet dry enough. Dried vegetables can easily absorb water from the surrounding air because of their low water content, so packing has to take place in a dry room. It is a good idea to finish drying during the warmest part of the day when the relative humidity is at its lowest. The product can be cooled in the shade and if the work has been done hygienically, the cooled products can be packed immediately.

The packing material must be waterproof, airtight and insect-proof. The dried products will only remain good if stored in such a way that they are dry and protected from insects. Normal plastic bags (properly sealed) will do for some time, but are not entirely gas and waterproof. It is also possible to use polymer-coated cellophane bags, which are water and airtight. These can be closed with a hot iron or a sealing

machine (where electricity is available). Unfortunately, this kind of plastic is not as easily obtained, and it is not too strong.

A plastic bag of a thicker quality (polyethylene, 0.05 mm thick) is the best. These can be closed tightly with a metal clip or with cellophane tape, although the quality of the closure also depends on the force with which the bag is closed and on the flexibility of the material. The plastic bags still have to be stored in a cool place and must be protected against rats and mice. It is therefore better to put a number of small bags in bigger jars or tins, which can be closed tightly as well. Small bags are useful, as the products will not absorb water despite regular opening of the tin. Each bag can best be filled with a quantity sufficient for one family meal.

Gourds can also serve as a packing/storage material. They must be closed well and smeared with linseed oil, varnish or other sealing material. Ground products absorb water quicker, so it is wise to grind them just before use, rather than storing the products in ground form. Properly dried and packed vegetables can be stored for about one year. After that, the quality can decrease quickly. Cool storage (e.g. in a cellar) makes longer storage possible.

## **5.6 Consuming dried products**

Soak the product in a small amount of water in a pan. Fruit should be soaked for 8-12 hours; the ratio of dried fruit to water is 2:3. Vegetables need only be soaked for half an hour; the ration of dried vegetables to water is 2:2.5-4.5. Products in powder form do not need to be soaked before they are consumed. After soaking, the product should be cooked for 10 to 15 minutes. Some types of fruit have a shorter cooking time than this, while others require even more time.

## 5.7 Three examples

### Drying potatoes

Choose potatoes that are firm and undamaged. Peel the potatoes, wash them under the faucet or in a container with clean water, and cut them in slices about 3 mm thick. Immerse the slices in boiling water, let them cook for 3-5 minutes, rinse them off with clean water, dry them with a clean cloth and place them on a piece of black plastic or on trays to dry for 2 to 3 days in the sun. Turn them regularly, about 2 to 3 times per day. The drying process is finished when the potatoes are hard and crumble easily when squeezed in your hand. The dried potatoes have to be soaked in water before they can be consumed.

### Drying tomatoes

Use firm, not too ripe, undamaged tomatoes. Wash and then cut them in half or in quarters (or in smaller pieces), and remove the seeds. Blanch the tomato pieces for one minute at 90°C and then allow them to cool off quickly under cold, running water. Once cooled, they have to be immersed for 10 minutes in water to which lemon juice has been added. Strain and then dry them with a clean cloth. Place the tomatoes on a piece of black plastic and let them dry in the sun. To make sure that they dry evenly, turn them 2 to 3 times per day. Place them under a shelter in the evenings. After 2 to 3 days they will feel brittle, and the drying process will have been completed.

### Drying mangos

Use firm, harvest-ripe mangos. The varieties Ameli and Kent are particularly good for drying. Wash and peel the mangos and then cut them in pieces about 6-8 mm thick. You can then choose to either blanch them in water at 56°C with two tablespoons of lemon juice added per litre of water, or immerse them in a 40% sugar solution for 18 hours, with the same amount of lemon juice added. In both cases, add 3 grams of sodium bisulphate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) per litre of water to prevent the fruit from discolouring and to protect it from moulds and insects. After this preparation, the pieces of fruit should be briefly rinsed with hot water to keep them from sticking together. Finally, place the

mango pieces to dry on trays, preferably made of plastic mesh (metal trays cause food products, especially fruit, to discolour quickly) and coated with glycerine to prevent sticking.

# 6 Preserving vegetables with salt and/or vinegar

Adding salt is one of the oldest ways to preserve food, except fruit, especially in areas that have easy access to inexpensive salt. Since salt absorbs much of the water in food, it makes it difficult for microorganisms to survive. There are two salting methods. One uses a lot of salt, and the other only a small amount. The disadvantage of using a lot of salt is that it has a very negative impact on the taste of the food. To overcome this problem, the food can be rinsed or soaked in water before it is eaten, but this also decreases the nutritional value of the food. It is therefore advisable to use a lot of salt only when there is a surplus of fresh vegetables and no other preservation method is possible. The use of a small amount of salt is in itself not enough to prevent the growth of bacteria, but it does result in the development of a certain kind of acid-producing bacteria that limits the growth of other bacteria. One example of a product made in this way is sauerkraut, which has a high nutritional value. Another way to preserve vegetables is by adding vinegar.

## 6.1 Preserving with salt

This chapter describes the two salting methods and the equipment that is needed. In both cases, the vegetables have to be hygienically prepared. Detailed information can be found in Appendix 5, which lists the method recommended and the amounts of salt needed per type of vegetable.

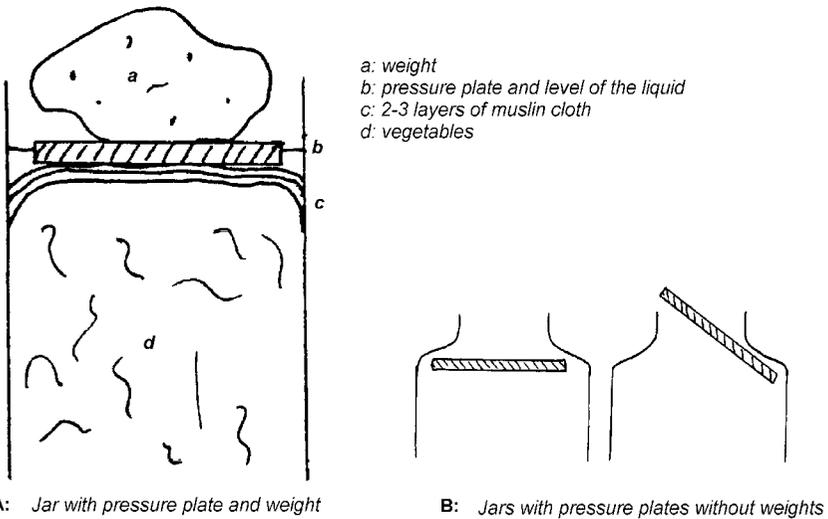
### Preserving with a large amount of salt

Heavy salting means that approximately 1 part salt is used for 5 parts of vegetables. This gives the vegetables a very salty taste, which makes it necessary for the vegetables to be soaked in water a few times before they can be eaten. The salt can be added as dried granules or as brine (a salt-water solution in various concentrations). Sometimes a little bit of vinegar also has to be added. Heavy salting is a

simple preservation method, and much less labour intensive than preserving with a small amount of salt.

**Heavy salting (20-25%)**

Mix the vegetables and the salt well, using 250 g of salt per kg of vegetables. Fill crocks with the mixture of vegetables and salt, cover with muslin cloth, a pressure plate and a weight, as shown in Figure 10. Add brine (250 g of salt per litre of water) until the pressure plate is just submerged.



**Figure 10: Different types of pressure plates**

After about two weeks the salted product must be repacked into smaller jars. These jars should only be big enough to contain enough for one meal, as contamination can occur quickly in an opened jar. Pour the remaining liquid from the crocks over the salted product in the smaller jars, until the vegetables are completely covered. Seal the jars tightly and then store them at as cool a temperature as possible.

Before using, the vegetables normally have to be soaked in fresh water for half a day (1 kg vegetables in 10 litres of water). However, the

vegetables lose nutrients during soaking, and this should therefore be avoided where possible, for example, when the vegetables are to be used in soup. Always cook the vegetables before use.

### *Heavy brine (20%)*

Fill the crocks or jars with the prepared vegetables (to which no salt has yet been added) as described in Figure 10. Pour the brine (in this case 200 g salt + 65 ml vinegar per litre water) over the vegetables until the pressure plate is just submerged. The required quantity of brine is about half of the volume of the vegetables. To maintain the proper salt concentration sprinkle 200 g of salt per kg of vegetables over the pressure plate. Store the crocks at 21-25°C and make sure that the vegetables remain under the brine. Add fresh brine (200 g salt + 65 ml vinegar per litre water) when necessary.

The vegetables have to be packed into smaller jars after about two weeks. Shell peas and brown beans if this has not been done yet. After repacking the vegetables add the old brine plus fresh brine where necessary so that the vegetables are submerged. Close the jars tightly. Before use, soak the vegetables as described above.

### **Use of small amounts of salt**

Enough salt is added to the vegetables to create appropriate conditions for the growth of micro-organisms that form acids, which will in turn preserve the vegetables. The acid gives the product a special taste that is often appreciated. Add 1 part salt to 20 parts of vegetables as dry salt or as light brine. When vinegar is also added to this light brine less salt is needed. The brine method is easier than the dry salt method, as brine gives an even distribution of salt and vegetables. This even distribution is a necessary condition for success. With the dry salt method, the product will shrink as liquid leaves the product. However, the colour, odour and taste are better when preserved with salt than with brine.

The preparation for salted or pickled vegetables is the same as for fresh vegetables, although longer cooking times are sometimes neces-

sary. A description of the equipment needed for salting and the special product data, followed by exact instructions, are given in this chapter.

### *Light salting (2.5-5%)*

One product made according to this method is sauerkraut. Mix the prepared vegetables with salt (25 g salt per kg vegetables; for green beans 50 g salt + 50 ml vinegar per kg). Fill the crocks with the vegetables and salt mixture, packing tightly. Cover the vegetables with several layers of muslin cloth, the pressure plate and the weight, as in Figure 10. The salt draws the liquid from the vegetables, which should gradually become covered with brine. If this does not happen within a few hours, add light brine (25 g salt per litre of water). Brine for green beans should be made from 50 g salt plus 50 ml vinegar per litre of water. Store the crocks at 20-25°C. The vegetables will undergo an acid fermentation lasting 2-3 weeks. Skim the froth regularly from the surface of the vegetables, using the following method.

A white layer of froth will appear on the vegetables after a few days when fermenting with the light brine and light salting methods (sometimes with other methods as well). This is caused by the growth of undesirable micro-organisms. If this froth is left undisturbed it will use up the acid from the fermentation process and can cause an unpleasant smell and taste in the vegetables.

The froth is best removed by first removing the weight and pressure plate and carefully lifting the muslin cloth, keeping the froth on the cloth. Rinse this, together with the pressure plate and weight, and replace these as shown in Figure 10. This treatment should be carried out every other day, especially when the froth is produced in large quantities.

If the vegetables are to be kept longer than 2-3 weeks, they have to be repacked into smaller containers after fermentation. Vegetables fermented in small jars do not need repacking. The fermented product is packed tightly into glass jars of 0.5-1 litre with a screw cap. Pour brine over the product until it is covered, using the old brine plus,

where necessary, fresh brine made from 25 g salt plus 50 ml vinegar per litre of water. Close the jars, but make sure that air can escape by twisting the lid closed and then giving it a quarter turn back (for the turn and lift caps, as illustrated in Figure 2, the turn back should be less than one quarter). Heat the jars in a boiling water bath for 25 minutes (for 0.5 litre jars) or 30 minutes (for 1 litre jars). The jars should be tightly closed immediately after heating. This process will pasteurize the contents and stop fermentation.

### *Light brine (5%)*

Fill jars or crocks with the prepared vegetables and cover with the muslin cloth, the pressure plate and the weight as in Figure 10. Add brine (50 g salt + 50 ml vinegar per litre of water) until the pressure plate is just submerged. You will need about half of the volume of the vegetables in brine. Keep the jars or crocks in a cool place (+/- 15°C). An acid fermentation will take place during the next 2-3 weeks. Remove the froth regularly (as described above). After the fermentation, it is best to repack the vegetables from the crocks into smaller jars with twist lids. Pack the glass jars tightly and add brine until the vegetables are submerged. Where necessary fresh brine can be made using 50 g salt + 50 ml vinegar per litre of water. Close the jars so that air can escape by closing the twist lid and giving it a quarter turn back. Pasteurize the contents by heating the jars in a boiling water bath (25 minutes for 0.5 l jars and 30 minutes for 1 l jars). Close the jars tightly immediately after heating. The vegetables need only be drained and rinsed before use.

## **6.2 Requirements for salting**

- *Salt*: this should be finely granulated and without a drying agent. Disinfect salt that is not pre-packed or that is locally extracted by sprinkling the salt on a metal sheet and heating this over a hot fire.
- *Vinegar*: use white or cider vinegar with a 4-5% concentration.
- *Jars and crocks or other vessels*: these can be made of wood, plastic, ceramic, glass or stainless steel. Barrels made from pinewood should be avoided as they can change the taste of the vegetables.

The jars must be very clean. Wash them in hot soda water and rinse with clean hot water.

- *Muslin cloth*: this is laid over the vegetables and under the pressure plate. The cloth is used to remove the froth from the surface of the vegetables.
- *Pressure plate*: this is a plate or grid of wood, ceramic, glass, stainless steel or plastic. A weight is put on top of this to keep the vegetables under the surface of the liquid. The pressure plate should be slightly smaller than the diameter of the vessel. A pressure plate that catches under the neck can be used with certain jars (see Figure 10B), in which case a weight is not needed.
- *Weight*: this is put on the pressure plate to keep the vegetables under the level of the liquid. The weight can be a clean stone or a water-filled glass jar (Figure 10A).
- *Scales and/or measuring cup*: these are needed to weigh or measure correct amounts of vegetables, salt and vinegar.
- *Knives*: stainless steel knives are needed to cut the vegetables.

### **Warning**

Peas, beans, sweet corn and greens preserved with salt always have to be cooked for at least 10 minutes before use. Do not eat (even for tasting) preserved vegetables that have not yet been cooked. It is important that the vegetables are always kept submerged below the level of the liquid.

## **6.3 Preserving in vinegar**

Pickling in vinegar or acetic acid can also preserve food. This method of preserving can be done with vegetables (cabbage, beets, onions, cucumber) and fruits (lemons, olives). To obtain a product that can be stored, the food first has to be salted and heated before being put into vinegar. An example of a vinegar-preserved food is Atjar Tjampoer.

When ordinary vinegar is used (5% acetic acid in water), it has to be heated in a closed pan. The utensils should be made of enamel or

stainless steel, because the high acid concentration of the vinegar corrodes other materials.

The vinegar should have a minimum concentration of 4%. (The pH has to be lower than 3.5; this can be checked with pH papers). The following vinegars can be used: white or cider vinegar (5% acetic acid) or pickling vinegar (concentrations vary up to 100% acetic acid).

Vinegar can be homemade by fermenting fruit juice with water and sugar. A kind of wine is produced first, which subsequently turns into vinegar when it comes in contact with the oxygen in the air. Experiment to find the best way to make wine and vinegar using local ingredients.

The following method is generally used: The prepared fruits or vegetables are put into cold heavy brine (200 g of salt per litre of water) for several hours, depending upon the size and shape of the product. Next they are put into a boiling salt solution, boiled, and cooled to 70-80°C. At this temperature the product (with herbs and spices if necessary, but without the brine) is transferred to jars. The jars are filled to 1.5 cm under the rim and the product is covered with warm vinegar so that all pieces are covered by at least 1 cm of the liquid. The jars are thus filled to 0.5 cm under the rim. The vinegar used must have a final concentration of about 5% after dilution. Always use clean glass jars (see previous chapters for information about cleaning and types of jars). Close the jars as quickly as possible and cool quickly in a cool, airy place. Store the products at as cool a temperature as possible.

Gherkins are sometimes fermented first (lactic acid fermentation) by storing them for some time in a salt-vinegar solution in crocks, after which they are packed into jars. If you have no previous experience with this process, caution is advised.

## **7 Jam and juice making, syrups, jellies and candied fruit**

There are several possible methods of preserving fruit. Canning, sterilizing and drying have already been dealt with in the preceding chapters. This chapter discusses the possibilities of making juice, jams, jellies and candied fruit. This can be done with all kinds of fruit. A mixture of two or more kinds of fruit often gives a better, more rounded taste in the final product. Apricots and peaches combine very well with orange or grapefruit juice. Orange and grapefruit juices can also be mixed. Pineapple is often mixed with orange, grapefruit, or apricot juice. The juices are best mixed before preserving, not just before use. Choose the proportion of the fruit in the mixtures according to your individual taste. The proportions have no effect on the shelf-life of the product. The methods described in this chapter are based on preserving with sugar or heat or a combination of these two.

It is best to start with fresh, undamaged fruit that is not overripe. Mouldy fruit increases the chance of spoilage and of causing food poisoning. Overripe fruit results in a tasteless or sometimes slightly musty-tasting product. All materials with which the fruit comes into contact, such as knives, pots, kettles, cans, pans and bottles, should be made of stainless steel, glass, undamaged enamel or good-quality plastic. Avoid using aluminium or galvanized tools and kettles, as the acid in the fruit will attack these. The acid can dissolve the aluminium and the zinc layer of the galvanized materials, resulting in a metallic taste and possible zinc poisoning.

This chapter first describes drink preparation, followed by methods for the preparation of other fruit products such as jelly, candied fruit, jam and chutney.

## 7.1 Making fruit juices

This section gives an overview of fruit juice preparation, followed by a description of different types of packing, bottling methods and storage of the bottled product. Examples are also given of the preservation of tomato juice and the preparation of fruit juice concentrates.

### Juice extraction

Preserved fruit juices keep their fresh taste and attractive colour as long as they are not heated for too long or at too high a temperature. Prolonged boiling or heating changes the taste, except with tomato and apricot juice.

Appendix 6 lists methods for the preparation and juice extraction of several types of fruit. Be sure not to heat the juice any longer than is indicated.

The extraction of fruit juice can be done in three ways. It is important to work as quickly as possible and to expose the juice as little as possible to the open air. Heating the fruit aids juice extraction and gives the juice a deeper colour. Heating also inactivates the enzymes and increases the shelf-life of the juice. The table below shows which fruits should or should not be heated before extraction.

*Table 2: Heating or not heating before extraction*

Heat before extraction		Do not heat before extraction
Apricots	Rhubarb	Apples
Berries	Tomatoes	Morello (sour) cherries
Red cherries	Plums	Green grapes
Peaches	Purple grapes	Citrus fruit
	Mango	

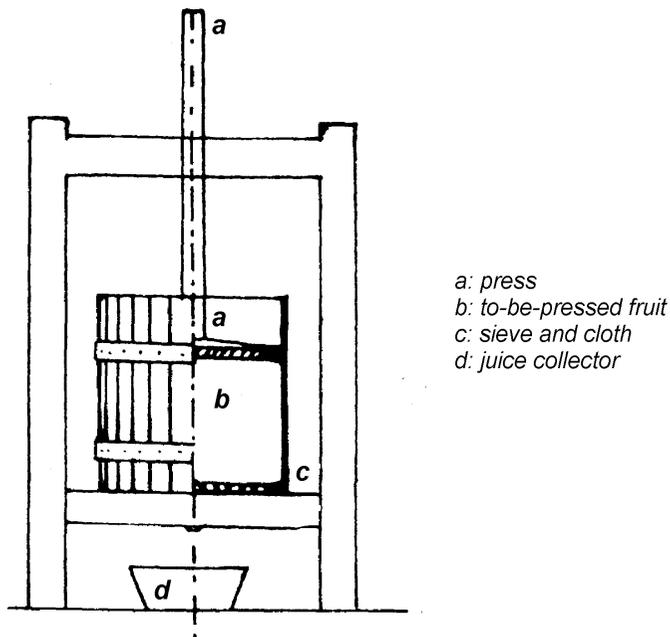
### *Method 1*

Clean the fruit and cut it into pieces. Heat the fruit with very little water until sufficient liquid has been extracted. Turn the mass onto a wet muslin cloth, put this into a sieve, and let the juice drip without

pressing or stirring. This gives a clear juice. More juice is obtained with squeezing, but this will make the juice cloudy.

### *Method 2*

This extraction method requires a fruit press or a fruit mill. Figure 11 shows a popular basket press. This method gives cloudy juice. The juice can be cleared by heating it to 60°C and then straining it through a cloth (use a clean, washed, finely woven cloth such as muslin or several layers of cheese cloth). The advantage of this juice is that it retains the smell and nutritional value of the fresh fruit, because the juice is extracted without boiling.

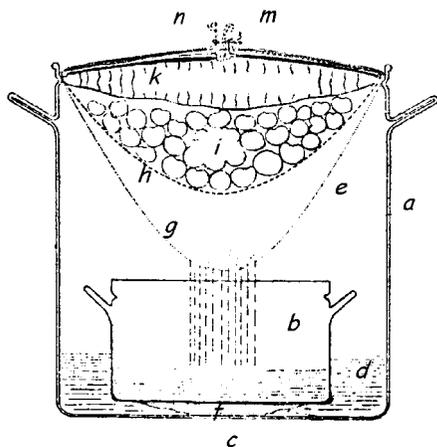


*Figure 11: Fruit press*

### *Method 3*

Steaming fruit is a labour-intensive method that produces a lot of clear juice. Wash and cut fruit into pieces (remove pits if necessary). Put the

fruit into a juice steamer (see Figure 12). Bring the water in the kettle to a boil and allow the steam to build up. The steam and the heat extract the juice from the fruit; the juice drips through the cloth and is collected in a small pan. For soft fruit this method takes about one hour, for hard fruit about 1 1/2 hours.



- a: sterilizer or washkettle*
- b: enamelled pan or stoneware dish, collecting the juice*
- c: heat source*
- d: water for evaporation*
- e: steam*
- f: supporting rack or plate*
- g finely woven cloth as a juice filter*
- h: coarsely woven cloth*
- i: fruit*
- k: condensation*
- m: muslin cloth tied around the lid*
- n: cork in the thermometer hole*

**Figure 12: Juice steamer**

The material needed for a juice steamer is:

- a kettle or pan with a lid without holes;
- a plate or grate which is laid on the bottom of the pan; a small enamelled pan or bowl or a dish of glazed pottery, which is put on the plate or grate to catch the juice (glazed pottery can sometimes contain a lead compound that can cause lead poisoning; be sure to inquire before using);
- two boiled white (preferably muslin) cloths, one of coarse weave and one of fine weave, that serve as juice filters and are pulled over the edge of the kettle or pan;

- a piece of strong parchment paper (grease-proof paper) to be put over the fruit on the cloth to catch the condensation.

Fruit can be processed using any of the three methods, but as mentioned above, apples, sour cherries (morellos), green grapes and citrus fruit are best squeezed without heating (method 2). The fruit pulp left over after extraction can be used as a spread on bread, with sugar added if necessary, or as a base for fruit yoghurt. Before bottling the extracted juices, one can add sugar and/or acid to them. Mixing sweet with sour juices is a good idea because it makes it unnecessary to add expensive sugar.

### **Materials**

Jars and bottles of 0.5-1 litre are best. Bottles bigger than 1 litre are less suitable, as they need a longer heating time. One-litre bottles are of course cheaper and easier to use than 0.5 litre bottles, as they hold twice as much juice. Clean jars or bottles with soda, sterilize (boil), and keep in hot water (95°C - 100°C) until ready for filling.

Jars: follow the manufacturer's instructions for heating the jars, lids and rubber sealing rings. If no instructions are available, heat the jars and lids in hot water just before use.

Bottles: use bottles that can be closed with metal tops. Always use clean tops that have never been used. Tops with a plastic layer on the inside are the best. Bottle tops with a cork layer inside can infect the product, while those with metal foil on the inside can give a metallic taste and cause food poisoning. Bottle top sealers are available. Make sure that the bottle sealer is properly adjusted, in accordance with the manufacturer's instructions.

Sulphured bottles: bottling in sulphured bottles is a special preserving method. A burning piece of sulphur ribbon is put into the washed bottle and the cork is put into place. When the bottle is full of sulphur vapour the ribbon is removed and doused in a bowl of water. The bottle is closed with the top and is held upside down for 10 minutes to

disinfect the cork. The vapour is let out of the bottle, which is then quickly filled.

### **Bottling fruit juices**

Sour fruit juices can be kept in cleaned and sulphured or sterilized bottles. Other juices can also be kept this way, but the chance of spoilage is greater. It is better to always pasteurize or sterilize in those cases. The juice can be pasteurized or sterilized in two ways. Either the juice is pasteurized first and then poured into the bottles, or the bottles are filled first and then pasteurized. Both methods are described below. The second method is preferable.

More information about pasteurization or sterilization can be found in Chapter 5.

#### *Method 1: Pasteurizing before packing*

The juice is heated in a pan and brought to boiling point, while being stirred constantly. Juice preserved in this way will have a mildly boiled taste. Better results can be achieved by placing the pan with the juice inside a larger pan containing boiling water. Stir gently but thoroughly and heat to 88°C. Remove the pan from the fire and fill the bottles or jars. Tomato juice cannot be treated in this way because of its low acid concentration. It must be boiled and sterilized (see below).

When the juice is ready for pouring, remove the bottles or jars from the hot water or reopen sulphured bottles. Fill all bottles or jars immediately to the brim with the hot juice. Remove any froth and add extra juice to fill the bottles again to the top. Keep the juice at the proper temperature (hold above a fire or in a hot water bath). If the temperature of the juice falls below 85°C, the juice must be reheated to 85°C. Put the tops on the bottles and invert them immediately for 5 minutes. Close the lids on the jars tightly and invert them for 3 minutes. Do not place the bottles or jars on a cold surface. Cool the vessels after turning (see cooling of bottles and jars, below).

### *Method 2: Packing before pasteurizing*

Remove the bottles from the hot water bath, drain quickly and fill immediately to 2 cm under the rim. When using jars the neck of the jar must be cleaned well, removing any spills, before the sealing ring and lid are placed on the jar. Ordinary bottles are sealed loosely with sterilized (boiled) corks, which are secured with string or with a damp piece of cellophane with a hole in the centre, again secured with string.

Fill a kettle or pan with water until it reaches the level of the juice in the bottle or jars. Bring the water to the boil (for sterilizing) or to 75°C (for pasteurizing) and heat the bottles for 20 minutes. After this, take the bottles out of the kettle, press the corks securely into the bottles or place a second piece of damp cellophane (without a hole) over the cellophane squares. Cover the bottles with a cloth and let cool to hand temperature (+/- 60°C).

Cooling of jars and bottles (for both methods 1 and 2)

When the bottles or jars are still hot to the touch, they can be placed into a big crock or pail with lukewarm water. After a few minutes, drain 1/3 of the water from the crock or pail and replace it with cold water. Repeat this once or twice. To remove the last of the heat, put the jars or bottles into cold running water for 5 minutes. Take care not to aim the flow directly at the bottles.

### **Storage of the bottles and jars**

Wipe the bottles dry and put them into a dark, cool and dry place. The lower the storage temperature is, the longer the shelf-life will be.

Hygienically prepared juices will not spoil quickly, even if they are stored in warmer places. However, they will slowly lose taste and vitamins, and their colour will change. At higher temperatures, for example 20°C and above, the loss will be faster than at lower temperatures. Check the bottles regularly for fungus and remove any bottles that show signs of spoilage. Never use the contents of these bottles.

## **Preservation of tomato juice**

Tomato juice is preserved by sterilizing it in a boiling water bath. Boil the pieces of tomato and press the pulp through a fine colander or sieve to remove the seeds and to soften the mass. Add, to taste, a tea-spoon of salt per litre of juice or 3-5 g citric acid. The bottling is the same as with the other juices. Pour the boiling juice into the bottles and close the bottles. Place the bottles and jars into a boiling water bath and heat them for 15-20 minutes (see section 4.4 for the correct way of using a boiling water bath).

## **The preparation of fruit syrup**

Where storage space is limited or bottles are hard to obtain, you can still make fruit syrups. For this method you need a lot of sugar. With most fruits, start with the juice obtained by extraction method 2. Boil the juice and add 1.5 kg of sugar per litre of juice. Dissolve the sugar while stirring. Skim the liquid (where necessary) and then allow it to cool. When using citric acid, first dissolve it in hot water and then let it cool. Mix the cooled lemon juice or citric acid with the syrup and then pour this into the bottles.

Fruits such as berries, cherries and plums should be ground down raw and forced through a sieve; oranges, grapefruit etc. should be squeezed. Sieve the juice, and then while stirring add the lemon juice or citric acid solution to taste and 1.5 kg of sugar per litre of juice. Cover the liquid, but remember to stir it regularly until all the sugar is dissolved. This can take a day or even longer. When all the sugar is dissolved, pour the syrup into bottles and close these tightly.

## **7.2 Preparation of other fruit products**

The following sections describe the preparation of fruit jelly, candied fruit, jam and chutney.

### **Fruit jelly**

Jelly is prepared from fruit juice and sugar. Extract the juice using method 3 (see section 7.1). Apple, grape, red currant, black currant

and elderberry juice are especially good for making jelly. A general recipe is given below.

Reduce the fruit juice to  $\frac{2}{3}$  of its original volume by boiling. While stirring, add  $\frac{3}{4}$  kg sugar per litre of reduced juice. Add, if desired, lemon juice or citric acid. Boil the jelly mass until a few drops, when sprinkled onto a plate and cooled, have the thickness of jelly. Skim off any froth. Fill well-cleaned jars with the jelly and seal these immediately with cellophane, a metal, glass or plastic lid, or with greaseproof paper. The jelly can also be covered with hot paraffin wax; after setting, this has to be covered with a second layer to completely seal all sides.

Another recipe for jelly, which uses less fuel but more sugar, is as follows: heat one litre of juice to boiling and add 1.5 kg of sugar. Boil for 5 minutes. Fill the jars and close as described above. Jelly can also be made with pectin (see directions on the pectin packet) or with albedo (the white of orange peel).

### **Candied fruit**

With candying, the fruit is slowly impregnated with sugar until the sugar concentration is very high, approximately 65 -70%. Peel and cut the fruit into pieces of 1-2 cm thick. Boil these pieces in water until they can be easily pierced with a fork. Soak them overnight in a 30% sugar solution. After this the sugar solution is increased by 10% and the mass is momentarily brought to the boil again before being allowed to stand overnight. This process is repeated until the sugar solution contains +/- 72% sugar. The sugar concentration can be checked with a sugar refractometer, a small, handy and inexpensive instrument.

Keep the fruits for several weeks in this saturated sugar solution of +/- 72% and then dry them. To prevent crystallization, the sugar solution must consist of glucose as well as beet or cane sugar. If this is not available, 'inverted' sugar can be used. This can be prepared by boiling a concentrated solution of beet or cane sugar for 20 minutes with a

generous dash of acid (vinegar, lemon juice, citric acid, hydrochloric acid, etc).

## **Jam**

Two methods for jam making are given below.

### *1. Volume reduction method*

Peel and cut the fruit into large pieces. Heat the fruit with a small amount of water in a covered pan until soft. Mash the fruit. Reduce the fruit to 2/3 of its original volume by cooking it in an uncovered pan. Stir the sugar (3/4 kg per 1 kg of fresh fruit) gradually into the fruit mass and boil for another few minutes. Lemon juice or citric acid can be added to increase acidity. Boil the jam until a few drops, scattered on a plate and cooled, have the thickness of jam. Skim the mass if necessary. Fill jars as described for fruit jelly. If you use a strong lid that can withstand heat, put the jars upside down so the hot jam will kill micro-organisms present on the lid.

### *2. Pectin method*

Pectin is a jelling agent used to set the jam. Follow the directions for use enclosed in the package. Apple pulp (apple sauce) or ground albedo (the white of orange peel) can be used instead of pectin.

## **Preparation of chutney and marmalade**

For 1 kg of fruit (tomato, rhubarb, etc.) use 1 dl vinegar (5%), 125 g brown sugar, onions, Spanish peppers, ginger powder and mustard powder to taste. Mix all the ingredients and heat it until thick. Complete the preparations using the recipe for jam making.

Marmalade is made from citrus fruit. The peel can also be used, in which case pectin is not needed. If the jam is to be kept for a long time, sodium benzoate can be added as a preservative. Use up to 250 mg per kg of jam.

## 8 Developing a small-scale food processing enterprise

If you are considering starting an enterprise for the preservation and processing of agricultural products or scaling up such an existing enterprise, it is important to think about the conditions required for success. An abundance of mangos or other product at harvest time is not sufficient reason to decide to process such crops. The questions to ask yourself have to do with the potential market, the availability of raw materials and the knowledge you will need about processing technology and organization of the enterprise. Although there may be opportunities to set up a successful enterprise, there are also many examples of failures. This chapter is intended to inform readers about the factors that influence success or failure of entrepreneurial activities in the field of processing.

The most important issues are:

- Market demand: What products (quality and quantity) could be sold and at what price?
- Raw materials: What quality and quantity of raw materials can be guaranteed?
- Processing technology: What is the right technology for processing, packaging, labelling and storing and what is the right processing capacity?
- Technical feasibility: Can maintenance and supply of spare parts be ensured? Are the right skills available and/or can training be provided? What hygiene measures should be taken?
- Financial feasibility: Is there a sound business plan? What risks are involved in moving towards another processing technology and/or larger processing capacity?
- Management: Is the right level of skills available for bookkeeping and management? What legal and administrative regulations are applicable?

Some publications in this Agrodok series provide valuable information related to some of the above issues: Marketing for small-scale producers is discussed in No. 26, which includes chapters on product selection, management, finance, cooperation and organization and cost price calculation. Storage techniques for tropical agricultural products are explained in No. 31. Preservation and processing techniques are discussed in this Agrodok (No. 3), No. 12 (fish and meat), No. 36 (dairy products) and No. 22 (weaning foods). For other subjects see the sources mentioned in Chapter 9.

## **8.1 Marketing a fresh or processed product**

Farmers produce food crops both for their own food supply and to sell at the market to earn an income. In either case, they could decide to store and/or process the crop for preservation purposes or to add value to the crop by extracting valuable components or producing composite products from it.

There are basically three options for marketing a crop:

### **1 Direct marketing of the harvested crop.**

The producer deals with traders who come to the village or to the farm, or the producer brings the crop to the market and sells it to traders or consumers. Transport is then a problem, but the alternative of regrouping products via a cooperative or other organizational form also makes it difficult to try and increase profits.

### **2 Temporary storage before selling the product.**

This option provides the possibility of increasing profits, making use of market price fluctuations. This can be organized at individual as well as community level in cooperatives or economic interest groups. Some form of credit or bank loans will often be necessary because after the harvest all kinds of costs or loans normally have to be taken care of.

### **3 Processing the crop before selling it to the market.**

This is the most complicated option of the three. For processing it will be necessary to know what products have a potential market;

processing equipment has to be selected and installed and the investment has to be financed; operators have to be trained and the raw material supply organized. This option demands a large managing capacity from the community or an experienced private entrepreneur.

To identify the opportunities to improve the production and marketing of traditional food products, one should carefully study the existing distribution circuit: determine how and why it functions. Reasons may be related to the perishability of the product and the availability of proper storage and preservation technology, but many will be related to the existing organization patterns, entrepreneurial experience and the availability of credit support.

The three above-mentioned options are characterized by an increasing complexity of organization. Especially when the farmers' community organizes itself to increase value added, it needs an increasing capacity for enterprise management as it moves from the first to the third option. In general, caution should therefore be taken in introducing new schemes to improve farmers' storage and marketing arrangements.

To analyse the constraints in production and marketing we mention a few conclusions from a study of the horticultural sector in Kenya:

- Production planning should be market-oriented. This is true for perishables, but also for processed products. Costs involved in storage and processing should correspond to the real market demand for the products.
- Farmers can organize themselves into farmer groups to go into trade and become less dependant on the middleman.
- Proper storage, grading and packaging decreases losses and generally increases the profits in marketing.
- Credit needs to be available to purchase trucks for transport, but also to finance other horticulture-related activities.

- Price information facilities are also very important. This aspect is mentioned as a major determinant for market integration and therefore improving marketing efficiency for horticultural products.

Among the most useful forms of assistance to help farmers and entrepreneurs establish and organize marketing systems is helping them find ways to improve their access, individually or collectively, to various services on a sustainable basis. Such services can include input supply, market information, information about technical alternatives for preservation and processing, business management training and access to credit.

*Listed below are some examples of organizations that receive assistance for storage, processing and marketing of food products:*

- *Profitable use of credit at community level exists in the Sahel region in sub-Saharan Africa. Cereal banks buy at harvest time about 10 % of the harvest and provide in this way some income to the farmers, while the cereal stays within the community. In the lean season villagers can buy grain from the cereal bank at a reasonable price and in that sense the cereal bank provides some food security. Because various villages have cereal banks, the banks also tend to have a stabilizing effect on market price levels. This kind of credit has worked with cereals, and it may very well be profitable for storage of other commodities as well.*
- *Groups of women in Uganda produce and export dried tomatoes to the UK.*
- *In Mali, a cooperative-based organization of farmers that produce and market fresh mangos developed semi-candied dried mango slices for the local market and for export to Italy.*

## **8.2 Organizing a processing enterprise**

Starting up a new processing enterprise, or scaling up or improving an existing one, often demands a change in the organization of the process and in the volume of raw materials to be processed, if the new technology is to be economically viable. The community or group

involved needs to have sufficient management and technical experience to be able to run the operation successfully. If this experience is lacking, a private entrepreneur should be approached to take on this task. Various forms of organization are possible:

- The village cooperative or interest group runs the processing plant and pays a salary to the machine operators and labourers.
- The village cooperative or interest group leases equipment from a local workshop that has sufficient experience in equipment manufacturing and maintenance.
- A private enterprise functions as a service mill and processes small batches for individual families, or larger batches on contract for the village cooperative.
- A private processing enterprise operating on a fully commercial basis buys raw materials from the village and the surrounding area.

A combination of these types of organizations is also possible.

As an example of the second form of organization, an analysis in a certain area in the Gambia showed that rice threshers and dehullers are mainly privately owned and operated, while coarse grain mills are owned by villages or communities. Private rice dehullers are more commercially oriented and operate at far lower transaction costs than village management committees. When a mill breaks down, transaction costs are very high and the women who manage the mill are forced to resort to hand pounding. Spare parts and maintenance services for the mills are provided by a government agency, but in an ineffective way, with the result that many mills stand idle for long periods. The private sector has not yet taken up the distribution of spare parts, but experience in importing these parts does exist and local artisans have the knowledge required to handle the maintenance. It was therefore proposed that rice processing equipment be leased from a workshop that is able to provide maintenance services and spare parts. Such a semi-private sector system can be seen as a step towards a fully privatized and decentralized network for the supply of equipment and spare parts and for repair and maintenance services.

For women involved in processing, the option of introducing organizational changes is often not very attractive. For many women, the main reason for being involved in processing or in any commercial activity is not to make large profits but to gain some additional income and thereby ensure greater economic security for the family. Micro-

economic enterprises in particular are attractive to women because of the flexible nature of the work, which makes it easier for them to combine work with domestic responsibilities. Consequently, it is not easy to expand their businesses because their family duties generally do not allow them to take risks and carry the obligations involved in larger businesses. Women certainly need greater access to credit and business advisory services; such services are generally not easily accessible to them. Women welcome credit schemes that make them more independent and their businesses more economically secure, but they tend to be less keen on using credit to expand their businesses significantly. This was demonstrated recently in a project in Burkina Faso aimed at expanding businesses run by women. The above-mentioned semi-private sector system would be an interesting option in that situation. Care would have to be taken, however, not to change gender relationships in a way that would be unfavourable for the women.

Several cases show that enterprises controlled by groups can become successful and make effective use of marketing and processing services offered by outside agencies (e.g. a bank or an NGO). The success of such groups is, however, less dependent upon the support of the outside agency, and more upon the motivations and intrinsic qualities of the group members, and the cultural milieu in which they operate. Failure is extremely common, and in no sense can successful groups be 'programmed' by an outside agency! Some case studies have taught us about the internal factors associated with success. They are:

- a clear member-driven agenda;
- purely financial objectives (rather than broad social objectives); and
- a high degree of self-financing.

To help groups organize processing in a sustainable way, the above list can be extended with lessons from other workers' co-operatives:

- Successful groups will come together on their own.
- Groups should not be compelled to adopt certain work practices.

- Organizational structures have to be developed by the people who work in them; they cannot be imposed by outsiders.
- Groups should receive training, but only in the subjects they ask for.
- There are good economic and managerial reasons for group enterprises not to grow too large. Outsiders should not impose or even suggest enlargement of groups. Members themselves must decide with whom they want to work.
- Training and advice should consist of telling members about what options are available, rather than telling them what to do.
- Agencies that assist are often tempted to provide more funds than the enterprise is able to manage. It is better to allow a group to grow organically by reinvesting its own profits.
- Freedom is important, but it implies freedom to succeed as well as to fail. Agencies can help with marketing but should never buy directly from the group; their assistance should be temporary and cost-effective, so that it helps people to be free.

The above is just a short introduction to the things that you have to deal with when starting your own enterprise. If you seriously plan to start your own business, we can strongly recommend the book *Setting up and running a small food business*, published by CTA (see “Further reading”).

# Further reading

The literature below provides more detailed information on specific topics discussed in this Agrodok.

**Processing and preservation of tropical and subtropical foods:** Kordylas, J.M. (1990), Mac Millan Education Ltd., Hong Kong, 432p. (ISBN 0333546695)

**Manual for preservation of food and condiments in the home:** Firueroa, V. and Lama, J. (1999), Community project: Preservation of Food, Calle 96 No. 5501, CP 11400, Marianao, Ciudad de la Habana, Cuba. 101p. (ISBN 959-7098-08-3)

**Prevention of post-harvest food losses: Fruit, vegetables and root crops:** Food and Agricultural Organization of the United Nations (1989), Rome, 154p. (ISBN 92-5-102766-8)

**Quality control in fruit and vegetable processing:** Board, P.W. (1988), Food and nutrition paper 39, FAO, Rome (ISBN 9251024219)

**Appropriate food packaging:** Fellows, P. and Axtell, B. (1993), TOOL Publications, Amsterdam, The Netherlands (ISBN 90 70857 28 6)

**Drying:** Oti-Boateng, P. (1993), Food Cycle Technology Source Books, Intermediate Technology Publications/UNIFEM, 50p. (ISBN 1853393088)

**Small-scale food processing: A guide to appropriate equipment:** Fellows, P. and Hampton, A. (1992), Intermediate Technology Publication in association with CTA, 159p. (ISBN 1 85339 108 5)

**Fruit and Vegetable Processing:** (1993), Food Cycle Technology Source Book, Intermediate Technology Publications/UNIFEM, 72p. (ISBN 1-85339-135-2)

**Packaging:** (1996), Food Cycle Technology Source Book, Intermediate Technology Publications/UNIFEM, 48p. (ISBN 1-85339-334-7)

**Traditional Foods; Processing for Profit:** Fellows, P. (1997), Intermediate Technology Publications, 288p. (ISBN 1-85339-228-6)

**Starting a Small Food Processing Enterprise:** Fellows, P., Franco, E. and Rios, W. (1996), Intermediate Technology Publications, 128p. (ISBN 1-85339-323-1)

**Training in Food Processing; Successful Approaches:** Battock, M., Azam-Ali, S, Axtell, B. and Fellows, P. (1998), Intermediate Technology Publications, 152p. (ISBN 1-85339-425-4)

**Try Drying It!:** Axtell, B. and Bush, A. (1991), Intermediate Technology Publications, 86p. (ISBN 1-85339-039-9)

**Profit for the Poor; Cases in Micro-finance:** Harper, M. (1998), Intermediate Technology Publications, 244p. (ISBN 1-85339-438-6)

**Setting up and running a small food business. Opportunities in food processing series:** Fellows, P.J. and Axtell, B. (2001), Wageningen: ACP-EU Technical Center for Agricultural and Rural Cooperation (CTA), 298p. (ISBN 92-9081-246X)

# Useful addresses

If you have specific questions about food preservation you can contact Agromisa or one of the organizations below:

## **ITDG**

*Activities:* Works with poor communities to develop appropriate technologies in food production. Website: [www.itdg.org](http://www.itdg.org) . ITDG publishes a magazine called “Food Chain” and has offices around the world:

**ITDG Sudan** PO Box 4172, Khartoum, Central Sudan, Fax 00 249 11 472002 E-mail: [itsd@sudanmail.net](mailto:itsd@sudanmail.net) and 43/2 Al QASR Janoub Avenue, South of Algorashi Park, Khartoum South, Sudan

**ITDG Eastern Africa** AAYMCA Building (Second Floor) Along State House Crescent P.O. Box 39493, Nairobi, Kenya, Fax: +254 2 710083 E-mail: [itdgEA@itdg.or.ke](mailto:itdgEA@itdg.or.ke)

**ITDG Southern Africa** PO Box 1744, Harare, Zimbabwe, 3rd Floor, Coal House, 17 N. Mandela Ave./Cnr. L. Takawira St. Fax: 00 263 4 771030 E-mail: [itdg@itdg.org.zw](mailto:itdg@itdg.org.zw) or [itdg@ecoweb.co.zw](mailto:itdg@ecoweb.co.zw)

**ITDG Bangladesh** GPO Box 3881, Dhaka 1000, Bangladesh House 32, Road 13/A, Dhanmondi R/A, Dhaka -1209 Fax: + 880 - 02 – 8113134 E-mail: [itb@itdg.bdmail.net](mailto:itb@itdg.bdmail.net)

**ITDG Nepal** PO Box 15135, Kupandol Lalitpur, Kathmandu, Nepal, Fax: +00 977 1 5-546185 E-mail: [itdg@wlink.com.np](mailto:itdg@wlink.com.np)

**Gambia:** GAFNA, Gambia Food and Nutrition Association, Kanifing Industrial Estate, PMB 111. Banjul, Fax: 390435

*Activities:* Intervention in fruit and vegetable processing, skills training and enterprise development.

**Ghana:** Ghana Regional Appropriate Technology Industrial Service (GRATIS), PO Box 151, Tema. Fax: 233-21-50-0092

*Activities:* Provides training and equipment services for food processing.

**India:** Action For Food Production (AFPRO), 25/1a, Institutional Area, Pankha Rd. D Block, Janakpuri, New Delhi - 110058, E-mail: [afpro@sdalt.ernet.in](mailto:afpro@sdalt.ernet.in)

*Activities:* AFPRO provides technical guidance and back-up support to grassroots-level NGOs in implementing environmentally sound food production, livelihood generation and related projects.

**Italy:** FAO Headquarters, Viale delle Terme di Caracalla, 00100 Rome, Italy, Fax: (+39 06) 570 53152

E-mail: [FAO-HQ@fao.org](mailto:FAO-HQ@fao.org), Website: [www.fao.org](http://www.fao.org)

For recipes: [www.fao.org/inpho/en/informations/cookbook/index.asp](http://www.fao.org/inpho/en/informations/cookbook/index.asp)

*Activities:* FAO publishes various books about food processing.

**Kenya:** Appropriate Technology Centre, Kenyatta University, PO Box 43844, Nairobi, Fax: +254 2 811575, E-mail: [atcentre@avu.org](mailto:atcentre@avu.org)

*Activities:* Fields of interest are food technology with specializations of post harvest and food preservation technology.

**Malawi:** TCC/PHN Women in Development Project, PMB 3, Namadzi

**Rwanda:** MADE, Micro Agro-Industries, PO Box 197, Kigali

**South Africa:** INFRUTECH, Private Bag X5026, 7599 STELLENBOSCH, Fax: +27 (0) 21 809-3400, E-mail: [unathim@infruit.agric.za](mailto:unathim@infruit.agric.za)

*Activities:* Knowledge on fruit processing and packaging.

**Tanzania:** SIDO, PO Box 2476, Dar-es-Salaam, E-mail: [sido@intafrica.com](mailto:sido@intafrica.com)

**Uganda:** USSIA: Small Scale Industries, PO Box 7725, Kampala

# Appendix 1: Pasteurization of fruits and vegetables

*Table 3: Preparation methods and packing liquid*

Product	Preparation	Add to product when packing into jar, bottle or tin
Apricots	Peel, split and remove pits	Cold 75% sugar solution
Applesauce	Make applesauce, reduce liquid, do not add any sugar	-
Broad beans	Shell, wash, boil in lightly salted water for 5 minutes	Boiling water
Carrots	Clean, wash, boil in lightly salted water for 5 minutes	Boiling water, plus salt to taste
Cauliflower	Cut, wash, boil 1-2 minutes	Boiling water
Cherries	Wash, remove stems	Cold water, sugar (sweet cherries need 25% sugar solution, sour cherries need 75% sugar)
Currant juice	Wash currents, remove stems, boil shortly, simmer 1 hour, strain if cloudy	-
Endive	Cut, wash, boil 10 minutes in 1% salt, pack tightly	Boiling water
Green beans	Wash, break, boil 10 minutes in lightly salted water	Boiling water
Mango	Steam 2 minutes, peel, slice, remove pit, pack into flat jars or tins	Boiling water, 40% sugar + 0.25% vinegar
Pears	Hard: peel, cook for 1/2 hour Soft: peel and cut	Cold water, 40% sugar
Peaches	Peel, halve and remove pits	Cold water, 40% sugar
Peas	Shell, wash, do not boil	Boiling water
Plums	Wash, peel if desired, halve, remove pits	Cold water, 40% sugar
Raspberries	Wash, sprinkle with 1/4 weight in sugar, let stand 2 hours before packing	-
Rhubarb	Clean, cut into pieces, sprinkle with 1/4 of the product weight in sugar. Pack with juices after 2 hours.	-
Snow peas	Remove ends, wash, boil in lightly salted water for 10 minutes	Boiling water

Product	Preparation	Add to product when packing into jar, bottle or tin
Spinach	Use fresh leaves only; wash, boil without water for 5 minutes with some salt, pack tightly	Boiling water
Strawberries	Wash, sprinkle with ¼ of product weight in sugar, let stand 2 hours before packing	-
Tomatoes	Wash	Warm salted water (1% salt solution)
Tomato puree	Wash tomatoes, boil for short time, strain, reduce juice	-
Turnip tops	Wash, boil for 5 minutes	Boiling water

*Table 4: Pasteurization times and temperatures*

Product	Pasteurization time (jars of 1-2 litre)	Temperature
Apricots	30 min.	80°C
Applesauce	30 min.	80°C
Broad beans	1 ½ hr	100°C
Carrots	1 ½ hr	100°C
Cauliflower	1½ hr, wash, boil 1-2 minutes	100°C
Cherries	30 min.	80°C
Currant juice	20 min.	75°C
Endive	1 ½ hours	100°C
Green beans	1 hr	100°C
Mango	10 min.	91°C
Pears	30 min.	80°C
Peaches	30 min.	80°C
Peas	1 ½ hr – repeat after 24 hr	100°C
Plums	30 min.	80°C
Raspberries	20 min.	75°C
Rhubarb	30 min.	80°C
Snow Peas	1 hr	100°C
Spinach	1 ½ hr	100°C
Strawberries	30 min.	80°C
Tomato puree	30 min.	80°C
Tomatoes	20 min.	80°C
Turnip tops	1½ hr	100°C

## Appendix 2: Sterilization in a boiling water bath

Unless otherwise stated, all products are blanched and sterilized in the boiling water bath.

*Table 5: Preparation and packing liquid*

Product	Preparation	Add to product when packing into jar, bottle or tin
Apples (whole)	Peel, blanch 3 minutes, pack tightly in jars or tins	Boiling water or 20% weight in sugar
Apples (slices)	Peel, remove core, slice, blanch 3 minutes in 1% salt	Boiling water or 20% sugar
Applesauce	Pulp apples, boil 10 minutes, pack at 82 C (minimum)	5 % sugar
Apricots	Remove stalks, wash, halve, remove pits	Boiling water, 25% sugar
Banana	Peel, cut into slices, pack into jars or cans immediately	Boiling water, 3.5% sugar + 0.5% vinegar + 0.1% calcium chloride
Berries	Remove stalks and overripe fruit, wash carefully	Boiling water, 30% sugar
Cherries	Remove stalks, wash, remove pits.	Boiling water, 30% sugar. For sour cherries add extra sugar.
Figs	Remove stalks, boil in 30% sugar until the syrup contains 65% sugar, fill at 100°C	Boiling water
Fruit puree	Prepare, pack into jars or cans at 70-80 C	-
Grapefruit	Peel, remove seeds, split segments, fill jars first with water	Boiling water, 40% sugar
Grapes	Remove stalks, wash	Boiling water, 15% sugar
Lychee	Peel, halve, remove pits	Boiling water, 50% sugar + 0.25% vinegar
Oranges	Peel, remove seeds, split segments	Boiling water, 15% sugar
Papaya	Peel, halve or slice	Boiling water, 50% sugar + 0.25% vinegar
Peaches	Boil 1 minute in water, peel, halve, remove pits	Boiling water, 25% sugar
Pears	Peel, halve, keep under water until packing	80 C water, 20% sugar

Product	Preparation	Add to product when packing into jar, bottle or tin
Pineapple	Peel, core, cut into rings	Boiling water, 30% sugar
Plums	Remove any overripe fruit, wash, remove stalks, halve, remove pits	Boiling water, 30% sugar
Sauerkraut	Boil 10 minutes and pack hot	-
Strawberries	Remove tops, wash	Boiling water, 20% sugar
Sweet pepper	Cut, (peel after boiling in 10% lye), blanch for 3 minutes, puree if desired	Boiling water, 1.5% salt
Tomatoes	Wash, steam 15 seconds, dip in cold water, remove skins	0.5% dry salt + 0.07% calcium chloride

*Table 6: Sterilization times and sealing temperatures*

Product	Sealing temp. °C	Sterilization times in boiling water bath (minutes)				
		Glass jars		Tins		
		½ l	1 l	0.58 l	0.85 l	3.1 l
Apples	60	20	20	15	15	20
Applesauce	82	5	5	5	5	10
Apricots	60	25	25	15	20	30
Banana	71	15	15	10	12	20
Berries	70	25	25	15	20	30
Cherries	70	25	25	15	20	30
Figs	95	15	15	15	20	30
Fruit puree	71	20	20	15	15	25
Grapefruit	60	10	10	15	18	20
Grapes	77	20	20	12	15	20
Lychee	77	15	15	10	12	20
Oranges	77	10	10	15	18	20
Papaya	77	20	20	15	20	30
Peaches	71	20	20	20	25	40
Pears	71	35	35	30	30	30
Pineapple	75	20	20	20	30	40
Plums	82	20	20	15	22	35
Sauerkraut	71	10	10	15	18	20
Strawberries	77	10	10	15	18	20
Sweet pepper	60	20	20	20	25	-
Tomatoes	60	45	45	45	55	90

## Appendix 3: Sterilization in a pressure cooker or autoclave

Unless otherwise stated, all products are blanched and sterilized in a pressure cooker or autoclave.

*Table 7: Preparation and packing liquid*

Product	Preparation	Add to product when packing into jar, bottle or tin
Beet root	Wash, blanch 20 minutes, peel (slice if desired)	Boiling salted (1%) water, sugar to taste
Broad beans	Shell, wash, blanch 3 minutes	Boiling salted (2%) water
Green beans	Wash, cut tips, break or cut, for young beans blanch 1 ½ minutes, for old beans blanch 3 minutes, fill, shaking tin to pack tightly	
Cabbage	Use only solid cabbages; cut, wash, blanch until soft (+/- 10 minutes)	Boiling salted (1.5%) water
Carrots	Remove tops and tips, blanch 5 minutes, peel and scrape, cut if desired.	Boiling salted (2%) water
Celery (roots)	Cut, blanch 4 minutes in 2% citric acid	Boiling salted (1.5%) water
Cauliflower	Cut into small rosettes (soak a few hours in 1% salt), wash, blanch 4 minutes in 0.5% citric acid	Boiling salted (1.5%) water, + 0.1 citric acid
Sweet corn	Remove kernels from cob, wash	Boiling salted (0.5%) water
Eggplant	Wash, cut into pieces +/- 2 cm long	Boiling salted (1%) water
Greens	Sort, wash <b>well</b> , blanch 3 minutes, add boiling liquid to the jars or cans first, then lower greens into the liquid	Boiling salted (3%) water
Mushrooms	Use fresh mushrooms, scrape caps, cut off base, soak in lemon juice 10 minutes, rinse with cold water, blanch 8 minutes	Boiling salted (2%) water + 0.1% citric acid
Okra (fermented)	Remove stems, soak in 2% salt for 18 hours, blanch 3 minutes, cut	Boiling salted (2%) water
Okra (fresh)	Blanch 2 minutes, rinse in cold water immediately	Boiling salted (2%) water

<b>Product</b>	<b>Preparation</b>	<b>Add to product when packing into jar, bottle or tin</b>
Olives	Soak in 1% sodium lye for 6-8 hours, oxidize in the open air, soak again in 1% lye for 6 hours, soak in water 4-6 days until all lye has been removed, then soak 1 day in 1% salt, 1 day in 2% salt and 1 day in 3% salt	Boiling salted (2%) water
Onions	Remove outer skins, blanch 5 minutes	Boiling salted (1.5%) water
Peas	Shell, wash, blanch 2 minutes, rinse with cold water immediately	Boiling salted (2.5%) water
Potatoes	Peel, wash, blanch 5 minutes	Boiling salted (1.5%) water
Pumpkin	Remove dirt, brush, halve, remove seeds, steam for 45 minutes	-
Salsify	Wash, scrape, blanch 5 minutes	Boiling salted (3%) water
Summer squash	Wash, halve, remove seeds, cut into pieces	-
Swedes	Wash, scrape, blanch 10 minutes, pack immediately	Boiling salted (2%) water
Sweet potato	Wash, cook, remove skin while hot, pack while hot	Boiling salted water or boiling sugar water to taste
Yams	Wash, cook, peel, pack while still hot	Boiling water
White beans (soya, kidney)	Peel, wash, blanch 3 minutes, big, dry beans need to be soaked overnight	Boiling salted (2%) water

**Table 8: Sterilizing in a pressure cooker or autoclave**

Product	Sealing temp. °C	Sterilization times (minutes)								
		Glass jars 115°C		Tins, 115 °C			Tins, 121 °C			
		½ l	1 l	0.58 l	0.85 l	3 l	0.58 l	0.85 l	3 l	
Green beans	74	35	40	21	26	37	12	15	22	
White beans	60	80	90	70	85	100	35	50	55	
Broad beans	71	35	40		30					
Beet root	71	35	40	35	35	50	23	23	35	
Cabbage	66			40	40	60	25	25	35	
Carrots	66	35	40	30	35	50	20	23	35	
Cauliflower	75			30			20	20		
Celery, roots	85	30	35	28	33	45				
Sweet corn	85	60	70	55	65	85	30	35	45	
Eggplant	71						35	40	60	
Greens	77	60*	65*				55	55	85	
Mushrooms	66	35	40	25	30		20	20	35	
Okra, fresh	66	35	40	35	40	55	25	30	45	
Okra, fermented	66			20	23	40				
Olives	66	60	70	60	70	70	45	48	50	
Onions	66			20		35				
Peas	71	40	45	36	50	55	25	35	40	
Potatoes	70	40	45	35	55	23	30	38		
Pumpkin	85	60*	75*	85	115	235	75	85	185	
Salsify	66			40						
Summer squash	66						25	35	40	
Swedes	66			30	30	40				
Sweet potato	70				34	40		24	32	
Yams	66			60	65	80	45	50	65	

\* These products need to be sterilized at 121°C in glass jars.

## Appendix 4: Preparation and drying conditions

Because the drying circumstances always vary somewhat, the numbers in the tables below should be seen as approximations rather than as absolute instructions. One must experiment to determine the best method for each situation and product. Extra information concerning specific products can be obtained from Agromisa.

### **Tray capacity:**

The figures are based on the use of single racks and sun drying. The capacity for artificial drying will be the same or higher, depending on the relative humidity and airflow speed.

### **Characteristics of the final product:**

A description of the final product has been given to help determine when the product is sufficiently dry, since the moisture content itself is difficult to determine without expensive equipment. When in doubt, use the local standards, especially when these contradict the information in the table.

### **Maximum temperature:**

The temperature of the product itself is difficult to measure, but the temperature of the drying air can be measured fairly easily. When the product contains much water the air temperature may be higher than the maximum given in the table, but at the end of the drying process this should be avoided. Measure the air temperature just above the product with a thermometer. Protect the thermometer against direct sunlight.

Drying information is given in the following three tables:

**Table 9: Fruit – preparation and drying conditions**

Product	Preparation	Drying conditions, remarks
Apples	Wash, peel, quarter and remove the core	-
Apricots	Wash, halve, remove pits	Spread on racks one layer thick with the cut side up
Bananas	Peel and cut in half length-wise or slice	-
Cherries	Wash and remove pits (this improves drying but decreases amount of juice)	-
Figs	Partly tree-dried, do not cut	-
Grapes	No usual preparation, sometimes a lye dip is given	-
Peaches and Mangos	Wash, halve, remove pits	Spread on racks with the cut side up
Pears	Wash, cut in half, remove the core and stems	Spread on racks with the cut side up. Max. 2 days in full sun, there-after shade
Pineapple	Peel and cut	Sulphite treatment* maximum temp. 60°
Plums	Sort by quality and size, immerse for 10 minutes in lye dip	Large plums should be turned occasionally

\* The authors advise you to request more detailed information from Agromisa if you want to apply the sulphite treatment.

**Table 10: Vegetables – preparation and drying conditions**

Product	Preparation	Blanching time (min)	Remarks
Beans	Remove tops and strings, wash, break by hand	5-8 min.	Dried products should not be packed directly in tins or bags
Cabbage	Wash, cut (5 mm thick), blanch immediately	3-4 min.	Moderately long storage
Carrots	Use fresh, young roots, wash, remove tops and tips.	None	Cut with stainless steel knife
Chillies Capsicum	Select, remove stems; do not cut little chillies, cut big ones into 5-10 mm pieces	None	Sometimes blanched
Eggplant	Remove stem and flower parts, wash and cut in slices 3 mm thick	2-6 min.	-

<b>Product</b>	<b>Preparation</b>	<b>Blanching time (min)</b>	<b>Remarks</b>
Garlic	Peel (not necessary when making powder), cut slices 3 mm thick	None	Can be ground to powder
Greens	Select, cut, wash	2 min.	-
Okra	Select, wash, remove stems, slice 6 mm thick	4 min.	Rinse after blanching
Onions	Peel, cut slices 3 mm thick	None	Can be ground to powder
(Sweet) potatoes	Wash, peel, remove eyes, slice 2-3 mm thick, dip in lemon juice to prevent brown discoloration	4-6 min.	Irish potatoes can be ground to a powder to be used as a thickener
Pumpkin	Remove stem and flower parts, cut, remove seeds, peel, slice 3 mm thick	3-6 min.	Need to peel when making powder
Tomatoes	Wash, dip in boiling water, peel, cut in slices 7-10 mm thick.	1½ min.	Rub paraffin oil on the rack to prevent sticking

*Table 11: Fruits and vegetables - product information for drying*

Product	Tray capacity kg/m <sup>2</sup>	Max. air temp. °C	Yield (kg) per 100 kg fresh product		Final product	
			Pre-prepared	Dried	Water content	Description
Apples	6	68	60	10	15-20%	buoyant
Apricots	4-8	66	90	18	18 %	leathery
Bananas	6		85	18	12%	hard
Beans	4	68	90	9-12	4%	brittle, dark
Cabbage	4	55	85	6-9	4%	tough, brittle
Carrots	4	71	80-85	8-9	5-7%	brittle
Cherries	25	74	80	28	25%	leathery
Chillies (capsicum)	6	60-65	85	10	5-7%	tough, brittle
Eggplant	4	65	90	10	5%	tough
Figs	6	71		20	15-20%	can be kneaded, skin flexible
Garlic	4	63			5-7%	brittle
Grapes	6	71	90	7	10-14%	can be kneaded
Greens	2.5	65	60-75	8-10	4%	brittle, crisp
Okra	4	65	90	9-12	5%	brittle
Onions	4	60	90	9	5-7%	brittle
Peaches/Mangos	6	68	85-90	15-20	14 %	leathery
Pears	6	65	80-85	15-20	10-15%	leathery
Plums	6	74	100	34	15-20%	can be kneaded
Potatoes	5	65	74	11	5%	hard, brittle
Pumpkin	4	70	70	7-12	5%	tough, brittle
Sweet potatoes	5	71	80-85	27	7-8%	hard, brittle
Tomatoes	5	65	70-90	4-5	5%	tough, brittle

## Appendix 5: Preparation of vegetables for salting

*Table 12: Preparation of vegetables for salting and the best method for each type of vegetable*

<b>Product</b>	<b>Preparation</b>	<b>Method</b>
Beets	See green tomatoes	See green tomatoes
Beet tops	See kale	See kale
Brown beans	See peas	See peas
Cabbage	Remove outer leaves and stalks; shred	light salting
Cauliflower	Remove stalks and leaves; cut into small pieces; no cutting is needed with the heavy brine method	light brine heavy brine
Sweet corn	Boil the cobs for 10 minutes; remove kernels	heavy salting
Green beans	Wash, cut off tips, blanch 5 minutes, cut into short pieces; whole beans can be used with the light brine method	light salting, heavy salting, light brine
Kale	Trim leaves; wash well, use the whole leaves	light brine
Lettuce	Wash, remove outer leaves and stalk; shred	light salting
Okra	Cut ripe okra into small pieces	See peas
Onions	Remove dry skins	heavy brine
Peas	Shell; with the heavy brine method, wait until repacking from big vats to small pots before shelling; do not use overripe peas with the heavy brine method; blanch 5 minutes	heavy salting heavy brine
Swedes and Turnips	Wash well; remove tops and bottoms; cut into small pieces	light salting
Sweet pepper	Cut length-wise, remove seeds and stem	heavy brine
Green tomatoes	Wash well, do not slice	light brine

## Appendix 6: Juice extraction methods

Sugar need only be added when a sweetened taste is desired.

*Table 13: Methods of juice extraction from various types of fruit*

<b>Fruit</b>	<b>Preparation</b>	<b>Method</b>	<b>Sugar</b>
Apples	Wash, use juice centrifuge, hand press or vegetable mill (fine)	Do not heat; press through a clean cloth or bag	none
Apricots/Peaches	Use solid ripe fruit; wash, remove stems	Boil in a little water until soft, strain or use a juice steamer	1 part sugar + 4 parts water + 5 parts juice or 1 part juice + 1 part water
Berries	Wash and crush ripe berries, heat to 80°C	Press through cloth; filter or use a juice steamer	If desired: 1 part sugar + 1 part juice
Cherries (Morellos)	Wash, remove stems and pits, cut, heat to 80°C (not for morellos)	Press through cloth or filter	If desired: 1 part sugar + 9 parts juice
Citrus fruit	Remove navels and seeds, do not heat	Juice steamer, do not press peel, do not remove pulp, use a coarse sieve	none
Purple grapes	Wash, remove long stems, dip in a muslin bag in boiling water for 30 sec., chop, let stand for 10 min.  Wash, crush	Press through cloth or cloth bag, filter, or use a juice steamer	none
Blue and green grapes	Wash, remove stems, chop, remove seeds; heat blue grapes to 71°C; do not heat green grapes	Press through cloth or cloth bag, filter	none
Mango	Wash and cut into pieces, boil for 5 minutes, separate seed from pulp	Mix pulp in blender / food processor, or use a juice steamer	none

<b>Fruit</b>	<b>Preparation</b>	<b>Method</b>	<b>Sugar</b>
Plums	Use ripe plums, wash and crush, add 1 litre water to 1 kg of fruit, heat to 82 C until soft or wash, cut	Press through cloth or cloth bag, or use a juice steamer	1 part sugar + 4 parts juice
Rhubarb	Wash and cut into pieces, add 2 litres water per kg fruit, heat until boiling or wash and cut	Press through cloth or cloth bag, or use a juice steamer	1 part sugar + 8 parts juice
Straw berries	See berries	See berries	1 part sugar + 3 parts juice
Tomatoes	Use well-ripened fruit	Press through a fine sieve	none salt to taste

# Glossary

- Enzymes:** Proteins specialized to trigger biological reactions, e.g. the conversion of certain organic substances into different ones.
- Fermentation:** Process by which enzymes, usually coming from micro-organisms, cause desired changes in taste, smell and texture.
- PH:** Level of acidity.
- Pasteurization:** Preservation method in which bottled or canned food is heated at a maximum temperature of 100°C. This process kills most micro-organisms and thereby increases the product's shelf life up to several weeks, but it is not as effective as sterilization.
- Spore-formers:** Type of bacteria that carry a certain type of seed that can withstand high temperatures and that grow into bacteria at low temperatures.
- Sterilization:** Preservation method in which bottled or canned food is heated at a temperature of 100 – 121°C. This process kills all micro-organisms, and extends the product's shelf life up to a maximum of one year, but it does not kill the spores, which can grow into bacteria once the container is reopened.
- Lye dip:** Soaking fruits or vegetables in a lye solution, which makes the product easier to dry and makes the peel easier to remove.