Home-based Fruit and Vegetable Processing in Afghanistan

A Manual for Field Workers and Trainers

Book One:

Principles of Post-Harvest Handling, Storage and Processing of Fruits and Vegetables

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Book One:
Principles of post-harvest handling, storage and processing of fruits and vegetables

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FOREWORD

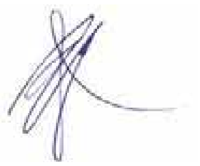
Afghanistan can be proud of the diversity of its agricultural products and the richness of its farming systems. And yet, despite this wealth of agricultural produce, in particular fruits and vegetables, many Afghan families do not eat sufficiently diverse foods, especially during the long winters and in the remote areas that are characteristic of Afghanistan. This lack of diverse foods is a major cause of malnutrition and micronutrient deficiencies which affect the majority of the population, in particular mothers and children.

Food processing is an essential way of helping Afghan farming households preserve their food and thus increase the availability and diversity of their diet throughout the year thereby reducing malnutrition and improving food security. It can also be a very good source of income for households: food processing helps reduce post-harvest losses; it enables households to sell their produce after the harvest season when prices are higher, and it also allows farmers to transport their produce to distant markets where they can obtain better prices for their produce.

The Ministry of Agriculture Irrigation and Livestock and FAO Afghanistan are proud to make this manual on the processing of fruits and vegetables available to Afghan farmers and their families, and to the dedicated workers who work by their side: agricultural extension workers, home economics officers, NGO workers, vocational trainers, school and literacy teachers, and other community mobilisers.

We thank those who join us in our goal of making the Afghan nation healthy and ready to build its future.

H.E. Obaidullah Ramin
Minister of Agriculture, Irrigation and Livestock
Government of Afghanistan



Tekeste Ghebray Tekie
FAO Representative
Afghanistan

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INTRODUCTION

Why is food storage and processing important in Afghanistan?

Afghanistan's climate is characterized by intense and long winters in many regions, notably in the Central Highlands, Northern Plains and in the Hindu Kuch range. The cold and snow limit the local availability of fresh foods, especially fruits and vegetables, and prevents the transport of fresh foods from other regions. Many families are thus exposed to high levels of food insecurity and malnutrition for many months, every year.

Food storage and processing can help Afghan families improve their diet throughout the year, by increasing the availability of diverse foods in the winter. Storing and processing foods when they are available in large quantities (after harvest) can also prevent wasting produce that cannot be eaten immediately. It can also help households increase their income in several ways:

- by adding value to food products
- by enabling them to sell produce after the harvest, when prices are higher
- by making produce easier to transport
- by decreasing the size and weight of the produce, and thus their transport costs.

Food processing is therefore particularly beneficial for households living in remote areas which are far away from markets.

Many Afghan families already use simple food storage and processing techniques, such as *drying* fruits and vegetables, or making *pickles*. However, it is possible to help them improve the quality of their processed foods and to diversify the techniques they use. Food processing can also be introduced in areas where it not yet common, which are generally food insecure areas (such as Bamyan, Badakshan, Ghor, Daikundi, etc.) where food processing can have a positive impact on household food security, nutrition and income.

Common problems related to food storage and processing in Afghanistan

Post-harvest losses of food in Afghanistan are generally high, for the following reasons:

- Fruits and vegetable are not sorted after harvest
- Produce are improperly handled during harvest, storage, transport and at the retail point
- Produce stay long periods in inappropriate storage conditions (too hot or cold, not ventilated and exposed to insects, rodents, and dust)

Food processing techniques often suffer from the following weaknesses and constraints:

- poor hygiene conditions, leaving foods exposed to dust and insects
- limited awareness and knowledge about simple food processing techniques
- low quality of processed foods, making them unsuitable for marketing or unsafe for consumption
- limited access to food processing equipment and materials, in particular packaging

Why was the manual written and for whom?

This manual provides information on how to improve the post harvest quality of fruit and vegetables in Afghanistan. It includes details of how to decrease post harvest losses through improved handling and storage and how to preserve fruit and vegetables for consumption later in the season.

The manual is aimed at processing and preservation for **home consumption** and as such, concentrates on techniques and processes that can be carried out at the **small-scale**, using a very limited range of equipment. It is limited to fruit and vegetables that are common in Afghanistan and to products that are already familiar to people. This manual aims to provide technical information, but using simple language, to make it usable by those who are not specialized in food technology.

The manual is suitable for a range of users wishing to promote and disseminate food processing techniques at community level. These include: agricultural extension workers, nutrition trainers, health workers, and teachers, working for government or non-governmental organizations. It can be used by trainers, as a reference manual, as well as students. The manual can also assist individuals wishing to engage in their own small-scale food processing enterprise.

Content of the manual

The manual is divided into two parts, which can meet the information needs of this diverse audience.

Book One provides the basic principles of food storage and processing. It describes optimal practices for each stage of fruit and vegetable handling, from harvesting, post harvest handling and storage, to processing and packaging. It provides technical information on the range of processes that are suitable for use by the small-scale processor. Book One also includes information on hygiene and *quality control*, both important issues at all levels of food processing.

Book One is especially useful for trainers wishing to understand the principles of food processing, as a background to practical trainings on specific food processing recipes.

A **glossary** at the end of Book One explains some of the more difficult technical terms that are used in the manual. (Words contained in the glossary are in italics in the text.) A list of **useful contacts** provides the user with details of organizations who are involved in small scale food processing and lists of potential suppliers of equipment.

Book Two provides a range of recipes for each food processing technique described in Book One, using fruits and vegetables available in Afghanistan. The recipes can be used as stand-alone guidelines and can be photocopied for wider distribution.

How was this manual developed?

The manual was developed by FAO Afghanistan with the Home Economics Department of the Ministry of Agriculture, Irrigation and Livestock, to respond to the needs of government and non-governmental organizations interested in disseminating food processing techniques in Afghanistan. The content was defined in consultation with representatives from these organizations who participated in a food processing training workshop organized by FAO Afghanistan in May 2006. It was completed following a review of traditional food processing methods and of existing manuals available in Afghanistan. It therefore took into account the needs and gaps in knowledge of small-scale home-based food processors.

Part 1 | Why do we Need to Process Fruit and Vegetables?

What is home-based food processing and why is it important?

Food processing covers more than just the preparation and cooking of the raw products.
It includes a range of simple processes that can be used to preserve fruit and vegetables for later use. These processes do not require expensive and complicated equipment and can be used at home or for small-scale enterprises. These will be described throughout this manual.

Box 1: What are the benefits of food processing?

- It can reduce post-harvest losses
- It can increase food security by making food available for the off season
- It adds variety to the family's diet, especially in winter months
- It can be used to earn an income by selling products in the local market, especially after the harvest, when food prices increase
- It is a simple activity that can be carried out at home, without the need for specialized equipment

How foods can become spoiled

Fruit and vegetables are living products that need to be handled carefully and properly to ensure that they stay in the best condition and are good to eat. The length of time a fruit or vegetable remains fresh and edible for is known as the *shelf life*. Some fruit and vegetables can be stored for a long time after they have been harvested, but others are more delicate and susceptible to spoilage and cannot be stored for long. Fruit and vegetables usually have a short growing season and a short *shelf life*.

Several factors cause fruit and vegetables to spoil:

- *enzymes* within fruits and vegetables
- *micro-organisms* (including bacteria and moulds)
- environmental factors, including temperature, moisture and sunlight

Enzymes within fruit and vegetables

While they are on the plant, natural chemicals (*enzymes*) within the plant cause the fruit and vegetables to grow, mature and ripen. The ripening process continues after they have been harvested. If they ripen too much, or get damaged during harvest or after harvest, they become spoiled and cannot be eaten.
It is important to stop the *enzymes* working. This can be done by heating the fruit or vegetable.

Micro-organisms – including bacteria and moulds

Bacteria and *fungi* belong to a general group that are known as ***microbes*** or ***microbial organisms***. Microbes are all around us – they live in the water, the soil and in the air and are on the skin of the fruit and vegetables and of the people that handle them. Some of the microbes that we come across in food processing are useful while others are not useful and can even be dangerous.

Sources of microbes:
Dirty water
Dirty hands
Coughs, colds and diseases
Dirty equipment
Over-ripe and damaged fruit
Exposure to animals, insects, and rodents
Exposure to animal and human waste (faeces)

Bacteria are present on the surface of fruit and vegetables and, if they are allowed to grow and multiply, they cause fruit and vegetables to rot and decay. Bacteria enter the fruit or vegetable through cuts on the surface or when the fruit is damaged, for example if the flesh becomes bruised during handling.

Food processing helps to get rid of the microbes and stop them from multiplying.

The environment - high and low temperature, moisture, sunlight

Fruit and vegetables are sensitive to changes in environmental conditions, especially to temperature, moisture and sunlight:

- High temperatures cause foods to spoil more rapidly than cool temperatures, because bacteria that cause spoilage multiply more quickly in the heat and can do more damage.
- High temperatures also cause fruit and vegetables to lose water, which reduces the quality of the product.
- Too little moisture can cause fruits and vegetables to wilt and lose their freshness.
- Too much moisture can promote the growth of bacteria and moulds.
- Sunlight causes chemical changes within the products which can change the taste, colour and quality of the fruit and vegetables.

Controlling food spoilage through processing

Processing can increase the shelf-life of fruits and vegetables by deactivating *enzymes* and destroying bacteria. Processing also transforms raw materials into new products. The food processing chain can be broken down into three stages:

- post harvest handling and storage
- processing
- post-processing packaging and storage.

It is important to control spoilage at each point in the processing chain. The following chapters explain how to control food spoilage and the best methods to use for each fruit and vegetable.

Part 2
Post-harvest handling and storage

Post harvest handling includes a range of processes such as grading, sorting, washing and packaging. It also includes the transport of fruits and vegetables and storage before processing. It is essential that fruit and vegetables are handled carefully after harvest so that they are in the best condition possible for processing and/or storage. Different types of fruit and vegetable require different forms of handling and care during harvest, storage and transport.

Optimum handling procedures for fruit and vegetables

Handling during harvest

During and after harvest, fruit and vegetables need to be handled carefully to prevent damage to the flesh. Juicy fruits such as berries damage more easily than the harder root vegetables. Bruised and cut fruits are more susceptible to bacterial damage as cuts in the flesh allow bacteria to enter the fruit and spoil the fleshy material.

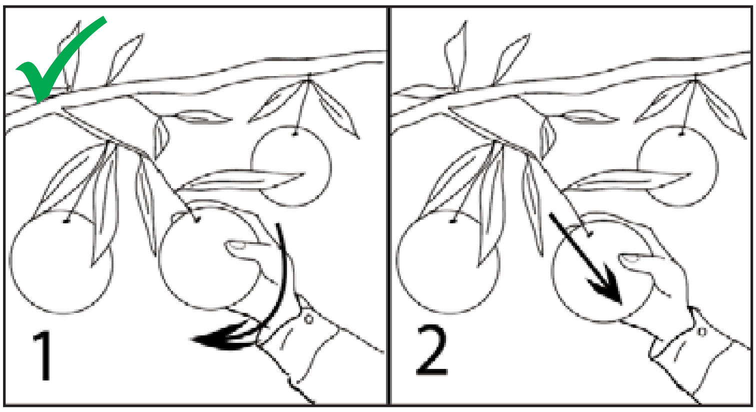


Figure 1: Good and bad handling at harvest

Box 2: Do's and don'ts when harvesting	
Do not...	**Do...**
Shake the tree or let fruit fall onto the floor **Squeeze or squash the fruits** **Drop the fruits on the floor** **Over-fill the collecting basket**	**Pick foods gently when they are ripe,** (take the mature fruit by hand, twist it a little bit and than pull it. If the fruit does not come away from the tree, then it is not ripe). **For mulberry picking:** place a big cloth under the branches, and then shake, to avoid the berries falling on the ground and becoming dirty or bruised. **Pack soft fruits in a single layer so the bottom layers do not get crushed.**

After harvest, temperature is the most important factor affecting the quality and *shelf life* of produce. High temperatures accelerate ripening and the speed at which fruit and vegetables decay.

The temperature at which a fruit or vegetable is harvested is known as the *field heat*. It is important to remove or reduce the *field heat* as quickly as possible after harvesting. This helps to prevent them losing water and keeps them fresh for longer. If the field temperature can be reduced by 10°C, the *shelf life* of the produce will double.

There are a few simple steps that can be taken to cool the produce after harvest;

- Pick the fruits from the tree early in the morning.
- Keep the produce in the shade.
- Spread the fruit out to allow heat to escape (piling the fruit in large heaps does not allow the heat to escape).

Figure 2: Spread out produce in the shade to allow heat to escape and reduce the *field heat*.

- If possible (depending upon the type of fruit), immerse it in cold or iced water (using clean water to avoid contamination).
- Spray water on the collected fruits immediately after harvest.

Sorting

Fruit and vegetables should be sorted to remove objects such as leaves, stones and sticks. Any immature fruit should be removed and set aside to ripen - some fruit species will ripen after harvest, while others will not. Diseased, damaged and over-ripe fruits must be sorted out and removed as these can infect the other fruit.

Figure 3: Sort fruit and vegetables to remove foreign objects and rotten fruit

Washing

Fruit and vegetables should be washed in clean water that is suitable for drinking. Dirty or contaminated water should not be used as this contains bacteria that can cause serious food poisoning if they are consumed (See the section on the preparation of clean chlorinated water, in Book Two).

Figure 4: Washing fruits and leaving them to drain

Packaging

Fruit or vegetables should be carefully packed into baskets, trays or crates for transporting to the processing site. The more fragile fruits need to be packed in single layers to prevent crushing those at the bottom.
It is advisable to sort fruits and vegetable by size, and package those of similar size together, for opimal use of space and to protect smaller produce from being damaged by larger and heavier produce.

Avoid packaging too many fruits or vegetables in one container, to prevent crushing and bruising of the produce. But avoid packaging too few fruits and vegetables into containers, to prevent the produce from moving around and becoming damaged during transport. Also, packaging too few produce together leads to loss of space and thus increased transport costs.

Figure 5: Packing crates

Optimum post-harvest storage conditions for fruit and vegetables

Storage conditions determine the *shelf life* of fruit and vegetables. It is important to control the temperature, *humidity* and ventilation within the storage area.

Effect of temperature on post-harvest storage

The ideal storage temperature depends on the type of plant and its origin. Plants which are native to tropical regions cannot tolerate the cold and must be stored above 12°C. Plants that are native to temperate regions can be stored at temperatures as low as 0°C. There are basically three groups of fruit and vegetables:

- those stored at 0 - 4°C;
- those stored at 4 - 8°C;
- those that require a storage temperature above 8°C.

For optimum storage, it is better to have a separate storage structure for each type of fruit and vegetable.

The importance of relative humidity (RH)

The *relative humidity* refers to the amount of moisture (or dampness) in the air, compared to the amount of moisture that would be contained in the air if it was fully saturated with water. Completely **dry air** has a *relative humidity* (**RH) of 0%** and air that is **fully saturated** with water vapour is **100% RH.**
During storage, we are interested in the *relative humidity* of the air within the store.

Fresh fruit and vegetables contain about 90% water. If they are stored in a very dry store room, they will dry out as water is lost from the produce (the leaves wilt and the vegetables such as carrots, potatoes and apples become soft). This process of evaporation (and spoilage) is more rapid at higher temperatures.

Most fruit and vegetables should be stored in a room that has quite damp air (85 - 95% *relative humidity*) (see Table 1). This prevents them from losing water. This can be done by:

- allowing the produce to reach storage temperature and then covering in plastic
- sprinkling the produce with water before they go into the store.

The importance of air flow and ventilation

It is essential that air can flow through the store room and circulate around the stored products. If there is no ventilation, heat will build up inside the store and the products will deteriorate. The humid conditions are ideal for the growth of bacteria and moulds, especially if the temperature increases.

The fruit and vegetables within the store must be checked regularly to see if they are still in good condition. You must remove any rotten or over-ripe products as they will cause the other fruit and vegetables to spoil.

Table 1. Optimum post-harvest storage temperatures for fruit and vegetables

Product	Temperature (°C)	Relative humidity (%RH)	Storage life
Fruit			
Apple	0-2	90-95	1-12 months
Apricot	-0.5 to 0	90-95	1-3 weeks
Cherry	-1 to -0.5	90-95	2-3 weeks
Grape	-1 to 5.0	85	1-6 months
Mulberry	0 to 5	90-95	1-3 weeks
Plum	-0.5 to 0	90-95	2-5 weeks
Vegetables			
Carrot	0	98-100	1-6 months
Leek	0	95-100	2-3 months
Okra	7-10	90-95	7-10 days
Pepper sweet	7-13	90-95	2-3 weeks
Pepper hot	0-10	60-70	6 months
Potato early	10-16	90-95	10-14 days
Potato late	4.5-13	90-95	5-10 months
Pumpkin	10-13	50-75	2-3 months
Spinach	0	95-100	10-14 days
Tomato mature green	18-22	90-95	1-3 weeks
Tomato firm ripe	13-15	90-95	4-7 days

The effects of ethylene

Ethylene is a gas that is produced by some fruit and vegetables when they ripen. Some fruits and vegetables are sensitive to the gas and will ripen if they are exposed to it. If *ethylene*-sensitive products are stored in the same place as *ethylene* producing ones, the sensitive ones will be spoilt during storage.

High *ethylene* producers include ripe bananas, cantaloupe melons and apples.

Ethylene sensitive products include lettuce, carrots, potatoes and cucumbers.

Storing ripe bananas, melons or apples with any of the sensitive products, such as lettuce or cucumbers, will cause them to ripen.

You can use this fact to your advantage. If you have unripe cucumbers that need to mature, you can store them with ripe bananas (or even the skins from ripe bananas) or apples to encourage them to ripen more quickly.

Box 3: Storing potatoes for food use - tips to reduce post harvest losses

When you harvest your potatoes, leave them out in the sun for a few hours to dry off and allow the skin to harden. Brush off any excess soil and check for damage. Check for holes on the outside of the potato as sometimes there are insects or other rodents inside the potatoes.

If you have damaged the potatoes during harvest, they cannot be put in the store. Sort out the diseased and damaged ones and use them as quickly as possible.

Potatoes are different to other root crops. They should be stored above 5°C. If they are stored at lower temperatures, the starch turns into sugars, which gives them a sweet taste. The optimum temperature range is between 5 and 10° C.

Potatoes also have a relatively high water content. If they are stored at low temperatures, or if they get damaged by frost, the water inside the potatoes freezes and spoils the potato.

The most important point when storing potatoes is to exclude light. If they are stored in the light, potatoes produce a poisonous chemical called *solanine* that makes them turn green. Partially green potatoes can still be used though - but you must cut off the green parts before you use them.

Potatoes that are stored for use as "seed" are best stored in diffuse light. The *solanine* and chlorophyll that form in the potatoes will help to protect the seed potatoes from insect pests and decay organisms. The *solanine* that forms in these potatoes makes them harmful so you should not eat potatoes stored for seed.

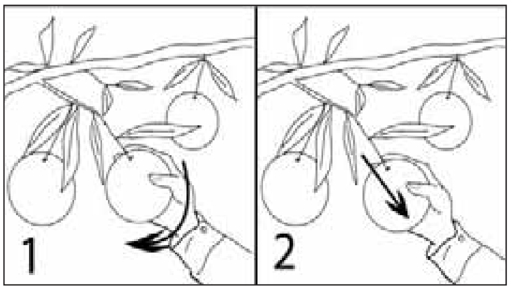
You can store potatoes in paper sacks but leave the neck slightly open so that moisture can escape. Do not use plastic bags as they make the potatoes sweat and turn rotten. The best container is a sack made from natural material such as a *hessian* sack or jute (a gunny bag) as it allows moisture to escape and air to circulate around the potatoes.

After the potatoes have been in the store for about a month, you need to empty them out and check for signs of damage or insects. If the potatoes are stored in a shed or storage pit that is not well insulated from the cold, you need to make sure that they do not get too cold, especially during winter. It is important that the potatoes do not freeze, therefore they should be covered with more insulation such as sacks, straw or old cloths during winter.

Potatoes are traditionally stored in a storage clamp out in the field. A clamp is made from wood or mud and bricks and covered with soil or straw for insulation. Clean healthy potatoes are piled into the clamp after harvest and covered in soil or straw. In very cold climates, extra layers of straw can be added for extra protection.

Annex 1 contains information on how to make your own storage clamp.

Quality assurance for post-harvest handling of fruit and vegetables



Harvest
Only pick the ripe mature fruits.
Do not shake the tree or let the fruits fall on the floor.
Take care not to cut or bruise fruit and vegetables

Sort
Remove immature fruits and leave to ripen.
Discard over-ripe and diseased or damaged fruits.
Remove sticks, leaves, stones and other material

Wash and drain
Only use clean or chlorinated water that is safe to drink.
Take care not to damage soft fruit during washing.
Drain well to make sure the surface water is removed

Pack and store
Use appropriate packaging boxes or crates.
Pack delicate fruits in single layers.
Store in a cool place away from direct sunlight
Control the temperature and humidity within the store.
Ensure the store is well ventilated

Storage structures

Characteristics of storage structures

A storage structure can be made out of locally available materials. The structure should have the following characteristics:

- It should be built in a cool, shaded area, possibly under trees to make use of the natural shade.

- It should be square rather than rectangular in shape as this helps to keep the interior cool.

- The walls should be as thick as possible so they insulate the building. A double walled building with a gap between the walls is more efficient at cooling. The gap between the two walls can be filled with wet sand or earth, which helps to cool down the walls and the interior of the building.

- The store house should be painted white or silver as this reflects the sun's rays. Dark colours absorb the sun, so heat up more quickly.

- Water can be used to cool the building.

- In cold climates you need to protect against frost. A double walled building insulates the inside against the cold. Build the two walls with a 15cm gap between the two. Fill the gap between the walls with dry straw to insulate the storage room. Cover the stored fruit or vegetables with straw or sacks to protect them from the frost.

It is essential that rats, birds and other pests cannot get into the store room. Chemicals, paints and other strong smelling products should not be stored in the store room as these can give the fruit and vegetables a bad taste.

Annex 1 provides examples of various storage structures

A simple evaporative cooler

When water evaporates from a surface it has a cooling effect. You can use this fact to make a simple cooling unit.

When dry air passes over a wet surface it absorbs water and at the same time produces a cooling effect. The efficiency of an evaporative cooler depends on the *humidity* of the surrounding air. Very dry air with a low *humidity* can absorb a lot of moisture and has the capacity to cause considerable cooling. Air that is saturated with water (in a very humid climate) will not be able to absorb any more water and will not cause any cooling. Evaporative coolers work well in Afghanistan, since the air is very dry in most provinces.

Figure 6: An evaporative cooler

The process of making and using an evaporative cooler is described in Annex 1.

Underground storage pits.

In some areas, underground storage pits and caves are used to store some vegetables, especially potatoes and other root vegetables. They are not suitable for soft fruits such as berries and apricots. Underground pits are well insulated by the earth above them and can maintain a similar temperature throughout the year. They can protect fruit or vegetables from extremes of climate. In warm climates, underground storage pits will be cooler than above ground and in cold climates, they will protect against frost. Underground storage pits are good in places where there is a frost, which includes most parts of Afghanistan.

The downside of underground storage is that there is little or no ventilation within the storage pit. There may be problems with the stored products rotting. It is essential to regularly check the condition of the products in store. Make sure that there is some ventilation and natural air flow within the store.

Annex 1 provides examples of storage pits and clamps, notably those suitable for potatoes.

Only good quality, undamaged and disease-free fruit and vegetables can be put into stores. Any diseased products will rapidly spoil the good produce.

Some fruit and vegetables can be stored together, but others cannot. It is important to know the storage characteristics and requirements of each product so that they are stored in their optimum conditions. See the paragraph on *ethylene* on page 14.

Part 3

Fruit and Vegetable Processing

After harvest, fruit and vegetables continue to mature and ripen and eventually become over-ripe, spoiled and unfit for consumption.
Food spoilage is due to a combination of:

- physical damage: bruising and cuts to the surface of fruit and vegetables during harvest and handling
- chemical reactions: enzyme activity that causes changes in the colour, flavour and texture of fruit and vegetables
- microbial damage that includes the growth of mould on the cut surfaces of fruit and vegetables and changes in texture of the flesh.

The *enzymes* within the fruit and vegetables and the *microbes* that attack them need to be slowed down or prevented from working altogether.

Box 4: The aims of processing are:

- to de-activate the *enzymes* that are naturally present in fruit and vegetables and that cause ripening and spoilage
- to destroy *bacteria* that spoil fruit and vegetables
- to improve the taste and make them edible
- to make them into new products which can add variety to our diets

Principles of food preservation

Most food processing and preservation techniques are based on the control of three basic factors which are essential for the activity of *microbes* and *enzymes*:

- ***Temperature***
- ***Moisture content***
- ***Acidity (pH)***

The food processing techniques that we will discuss in the following sections, and which are the best ones for preserving fruit and vegetables use a combination of these three factors:

- Heating – increases the temperature and reduces the water content
- Cooling – reduces the temperature
- *Drying* - reduces the water content
- Salting – reduces the available water content
- Sugaring (e.g. *Jam* making) – reduces the available water content.
- Pickling/*fermentation* – increases the acidity

The different processes can be used alone, but in many food processing operations, they are combined to give an enhanced effect.

The food processing techniques that are most suitable for use at the home level include *drying*, heating, pickling and salting. Sugaring – the addition of sugar to fruit such as when making *jam*, *jelly* and candied fruits - is a technique that can be readily used at the home level, but it should be used with caution as the amount of sugar required can sometimes be prohibitively expensive.

Temperature control

Most *micro-organisms* need temperatures in the range 20-30°C to grow and multiply. This corresponds to the daytime temperature from March to October in Northern and Central regions of Afghanistan and from February to May and September to November in Southern and Eastern Afghanistan.

Outside of this range they either die or their growth is inhibited. Heating and cooling are both effective methods of controlling microbial activity.

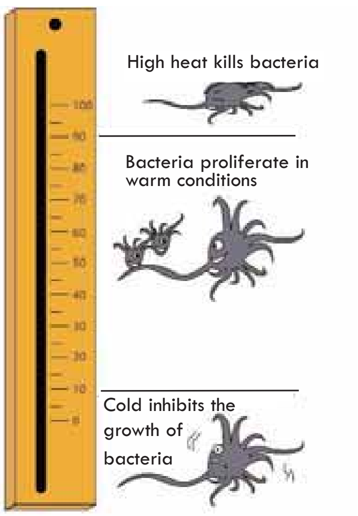


Figure 7: Very high heat and very low temperatures kill bacteria or stop their growth.

Heating

Heating kills bacteria and stops *enzyme* activity. There are several methods of heating:

- ***Boiling***, such as when making *jam* and sauce. *Concentration* by *boiling* (eg *jams* and sugar confectionery) use higher temperatures (105-120°C) and longer heating times to destroy nearly all the *micro-organisms* in a food. It also reduces the moisture content of the food.

- ***Blanching.*** Pieces of vegetable are put in water at above 90°C for several minutes. This kills the *bacteria* on the surface of the vegetable and stops any *enzyme* activity.

- ***Pasteurisation.*** *Pasteurisation* uses temperatures lower than that of *boiling* water and so preserves the taste, colour and nutritive value of the product. *Pasteurisation* extends the storage life of bottled fruits and juices, as well as sauces and purees, by several months.

At the small-scale, it is best to *pasteurise* fruit juices, sauces and *pickles* in their containers after packaging. This is the best method as there is no risk of contamination after the process. The time and temperature needed for *pasteurisation* depends on the size of the container and the acidity of the product (see table 2 below).

The temperature used for *pasteurisation* is fairly low (63 to 75°C). The product is held at the temperature for up to 30 minutes.
After heating, the bottles are cooled to room temperature by placing them in a pan of cool water. If very cold water is used there is a danger of breaking the glass. You need to test the temperature of the water using a thermometer.

Table 2: Pasteurisation time for different bottle sizes

Bottle size (litres)	Pasteurisation time at 80°C (minutes)
0.33	10
0.5	15
0.75	20

- Heat ***sterilisation*** (canning and bottling). *Sterilisation* is a similar process to pasteurisation that is used to extend the storage life of bottled or canned products. It requires specialised equipment and therefore is not recommended for use at the small scale.

Cooling

At cool temperatures *bacteria* are slowed down but not killed. Cooling is more difficult to do at the small-scale as it requires a refrigerator or freezer to store the products.

Control of moisture content

Water is essential for the growth of all animal, plant and microbial cells. If it is removed or made unavailable, then growth and activity are decreased.

> The most appropriate forms of temperature treatment for use at the household level are *blanching, boiling* and *pasteurisation.*

Food preservation *techniques* that reduce the amount of water available for *microbe* use are described as '***concentration*' techniques.**

The most well known method of removing water from fruit and vegetables is *drying*. Dried foods have a fairly long *shelf life* as *bacteria* cannot grow on dried foods.

The addition of salt or sugar to fruit and vegetables is another well known form of preservation. The salt or sugar combines with water inside the fruit or vegetable and makes it unavailable for the *bacteria* to use.

> The most appropriate forms of preservation using moisture control for the household level include drying, salting, sugaring (including jam-making) and sauce-making.

Regulation of acidity

The strength of an *acid* or *alkali* is measured using a *pH* scale. A very strong *acid* has a *pH* value of 1 while a very strong *alkali* has a *pH* value of 14. Products that are neither *acid* nor *alkali* are said to be ***neutral*** and have a *pH* of *7*. Most foods have a *pH* of *7* or less and are classified into three groups, described in table 3.

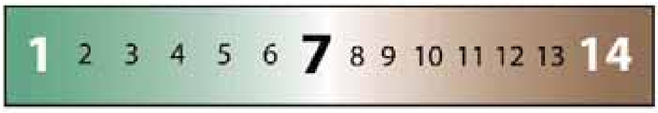


Figure 8: High acid foods have a low pH (below 4.5), low acid foods (alkali) have a high pH (above 5.3). A pH of *7* indicates neutrality.

Table 3. The acidity of common fruit and vegetables

Acidity of common fruit and vegetables		
Low (pH>5.3) Spoils easily	**Medium (pH 4.5-5.3)**	**High (pH< 4.5) Spoils slowly**
Carrot	Pepper	Apple
Leek	Pumpkin	Apricot
Okra	Watermelon	Cherry
Potato		Grape
Spinach		Plum
Melon		Tomato
Cabbage		Citrus fruits e.g. "kinu", lemon, orange

Most *bacteria* cannot survive in acidic conditions, therefore high *acid* foods are less prone to bacterial spoilage. Foods that have a low *acidity* (high *pH*) allow *bacteria* to grow and multiply and are more prone to spoilage. Some *bacteria* (especially those that produce ***lactic acid***) can tolerate more acidic conditions (a *pH* as low as 3.8). *Yeasts* and *moulds* can grow in *acidic* foods (a *pH* as low as 2.5).

The *acidity,* or *pH* , of foods can be increased by adding *acid* such as citric *acid* (found in citrus fruits) or *acetic acid* (vinegar) to control the growth of food-poisoning *bacteria.*
It is also possible to increase the acidity of foods through ***fermentation***.

Fermentation is a method of food preservation that uses *bacteria*. During *fermentation*, the *bacteria* break down the sugars present in fruit and vegetables to produce an *acid* which helps to preserve the food. A range of products, including vinegar and fermented *pickles*, can be made by fermenting fruit and vegetables.

There are two main types of *fermentation* that are important in the processing of fruit and vegetables. These are:

- *Lactic acid fermentation* which results in the formation of *lactic acid*, which helps preserve the food.
- *Acetic acid fermentation* which results in the formation of *acetic acid* (also known as vinegar – see the section on vinegar for more information on this *fermentation*).

The most useful forms of acid treatment for use at the home level are the preparation of pickles using vinegar and the lactic acid fermentation of fruit and vegetables.

Overview of fruit and vegetable processing techniques

Differences between fruits and vegetables

Although there are many similarities between the processing of fruit and vegetables, it is important to remember the following main differences:

Fruits are nearly all **acidic** and are commonly called '***high acid foods***'. The natural *acid*ity controls the type of *micro-organisms* that can grow in fruit products and influences the type of processing technique that should be used. The spoilage *micro-organisms* that are likely to be found in fruit products are *moulds* and *yeasts* which, if consumed, rarely cause illness. Processing of fruits generally uses *preservatives* such as sugar, salt and vinegar and the techniques used include *drying*, *concentration* and *fermentation*.

Vegetables are less acidic than fruits and for that reason are classified as '***low acid foods***'. A wide range of *micro-organisms* can grow in moist low-*acid* foods which may lead to spoilage and the possibility of food poisoning if they are consumed. To prevent this, vegetables need to be processed to destroy the *bacteria*. The best methods to use are heating, which destroys *bacteria*, and pickling, salting and *drying* which all inhibit bacterial growth.

Summary of small-scale fruit and vegetable processing techniques

The most suitable processes and products for the small-scale preservation of fruit and vegetables include the following:

- Dried fruit and vegetables
- Jams and marmalades
- Chutney and sauces
- Pickles
- Vinegar

The preservation techniques listed in Table 4 reduce the number and activity of *microbes* and slow down the activity of *enzymes* within the food. They are all suitable for home processing as they can be made using equipment that is found in the home. Only a few processes require special equipment.

Table 4: Description of main pre-treatment and processing techniques with their equipment requirements.

Process/product	How it works	Equipment needed
Pre-treatments		
Washing in clean water	Reduces the number of bacteria on the surface of the fruit or vegetable.	Plastic bowls and buckets
Blanching	Heat treatment to kill bacteria and stop enzyme activity.	Large pan for *boiling* water. Heat source
Sulphuring and *sulphiting*	Stops browning of fruit caused by oxidation. Preserves the colour of the fruit or vegetable. Kills bacteria and reduces the growth of mould and *yeasts* in the dried fruit.	Rock sulphur and sulphur box or tent Or: *Sulphiting* solution, pot, heat source
Preservation techniques		
Heating	Kills bacteria. Stops enzyme activity.	Large pan. Heat source
Cooling	Slows down bacterial activity. Slows down enzyme activity.	Pot cooler or cool chamber
Drying	Removes water - reduces bacterial activity and enzyme activity.	Dry, warm climate; suitable area for *drying*. Small dryer
Concentration (*boiling*, filtering, pressing)	Reduces the water available for bacterial growth.	Large pan. Filter cloth Heat source
Fermentation	Increases the acidity of the food - reduces bacterial growth and activity.	Large plastic bucket
Addition of salt or sugar	Salt and sugar reduce the water available so microbial activity is reduced.	Large pan, weighing scales Salt or sugar
Addition of chemicals (*acetic acid*, citric acid, benzoid acid, metabisulphite)	Several chemicals are used during food processing. Some are useful and essential for preservation, while others are not essential and may even be dangerous to health. *Acetic acid and citric acid* increase the acidity and reduce bacterial activity. There is no limit to their use. *Sodium benzoate* (*benzoid acid*) is sometimes added to products that are not all consumed after opening (fruit squashes, sauces, pickles). It is added at a rate of 0.03-0.2%. Sodium or potassium metabisulphite is used to retain the colour in dried fruit and vegetables. It is added at a rate of 0.005-0.2%.	Large pan, weighing scales Chemicals
Pasteurisation	Kills bacteria and stops enzyme activity.	Large pan, heat source, thermometer

The use of chemical additives in food processing

Sodium or potassium benzoate can be added to fruit products to control the growth of *mould* and *fungus*. They are usually added to products that are opened and not used in one go, for example fruit squash. It is not essential to add these *preservatives* to products that have been properly processed or are stored in good conditions, but they can help to extend the *shelf life* of certain products. Some countries do not permit additives in food products. Some consumers prefer foods that do not contain additives.

Food colourings should be avoided. They are not required in any of the products in this manual. Some food colourings are toxic and dangerous to health. They do not add any value to the product. Many consumers prefer to eat foods that do not contain colourings.

If you follow the principles of food preservation and good hygiene, then it is not essential to add any of these preservatives.

Food preservatives should not be used to cover up for poor hygiene practices!

The effect of processing on nutritional quality

Fruit and vegetables are a good source of vitamins and minerals, which are essential components of a balanced diet. The concentration of vitamins and minerals is highest in raw fruit and vegetables. All forms of processing reduce the levels of vitamin and minerals in the foods, but some have a greater effect than others. You can minimise the loss of vitamins and minerals from fruit and vegetables by choosing gentle processing methods.

Vitamins are the most sensitive food components and it is these that are often lost during food processing. Minerals are less sensitive and not as badly affected by processing. The most important vitamins found in fruit and vegetables are vitamins C and A (in the form of beta-carotene). Most vitamins are sensitive to heat, light and exposure to the air.

Food processes that involve *heating* for a long time (such as *boiling* to concentrate sauces, *jams* and chutneys) lead to high losses of the vitamins.

Blanching is a good form of pre-treating vegetables. It should be used prior to *drying* because it destroys the *enzymes* and *microbes* that cause spoilage and helps retain a good colour. It reduces the vitamin content, but does not lead to high losses.

Drying is one of the gentlest food processing methods as the fruit or vegetables are not exposed to direct heat. However, direct exposure to sunlight will reduce the levels of vitamins C and A and cause the colour of fruit and vegetables to change:

- Green vegetables will darken if they are dried in direct sunlight.
- Orange or red fruit and vegetables will fade if they are dried in direct sunlight.

To preserve the nutritional quality of dried fruit and vegetables, it is important to shade them from the direct sun. You can do this by placing a portable shelter made from straw over the dryer. Or you can include a dark sheet of corrugated metal inside the dryer to act as a sunshade.
Once the products have been dried, it is important to store them away from direct sunlight as this can reduce the levels of vitamins still further.

Fermentation of fruit and vegetables for pickle making has a minimal effect on the nutritional quality.

Table 5: Effect of different types of processing on vitamin content

Form of food processing	Effect on vitamin content
Heating for a long-time (e.g. *boiling*)	High loss of vitamins
Blanching	Medium loss of vitamins
Drying	Low loss of vitamins *if not exposed to sunlight*
Fermentation	Minimal loss of vitamins

Processing pre-treatments for fruit and vegetables

To get the best quality fruit and vegetable products, there are several *pre-treatment* steps that can be carried out.

Washing

Washing is one of the simplest food processing operations that you can carry out, but one of the most important. Fruit and vegetables should be washed to remove surface dust and dirt and any bacteria that may be contaminating the outer skin. If you do not wash dirty fruit and vegetables, the dirt and bacteria will be transferred onto the inside flesh when you remove the peel or chop into smaller pieces. Only clean, chlorinated water should be used for washing. The washing water must be changed frequently. If you wash in dirty water you contaminate clean fruit and vegetables.

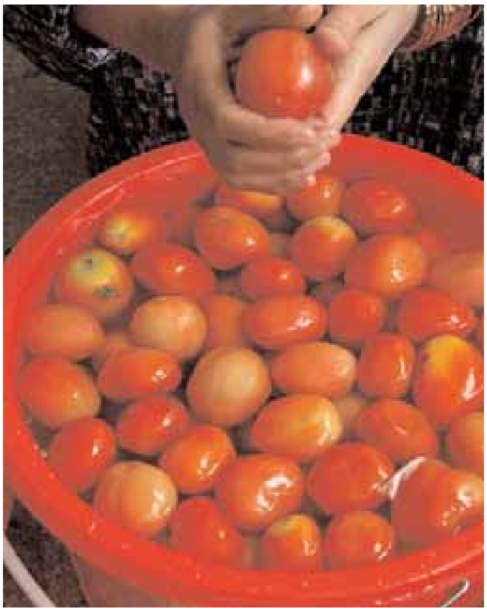


Figure 9: Wash fruits and vegetables thoroughly in clean water before processing

Blanching

Vegetables are blanched to inactivate the *enzymes* and reduce the number and activity of bacteria. The cut pieces of vegetable are placed in *boiling* water or held in steam for up to 5 minutes. *Blanching* is usually done before a vegetable is dried to improve the quality of the dried product.

Figure 10: Blanching of vegetables

Blanching is used for hard vegetables such as carrots, beans and peas as it helps to preserve a good colour and softens the vegetable so that it dries more quickly later on. It is not used for soft vegetables or fruits such as tomatoes, onions and peppers.

Sulphuring and sulphiting

Sulphur dioxide is used to preserve the colour and increase the *shelf life* of dried foods, especially of fruits. It cannot be used to treat red fruits such as cherries as it bleaches the flesh. It is commonly used to preserve apricots.

Figure 11: A sulphur tent for sulphuring apricots in Wardak province

There are two methods of treating fruit with sulphur – using *sulphur dioxide* gas (*sulphuring*) or dipping in a sulphite solution (*sulphiting*). *Sulphuring* is more common for fruits and *sulphiting* for vegetables. *Sulphuring* uses rock sulphur which might be easier to purchase than the chemical sodium or potassium metabisulphite. One disadvantage of *sulphiting* is that it wets the fruit which makes the *drying* period longer.

Care should be taken when using sulphur or sulphite as the gas is not pleasant and can cause breathing problems. It should be carried out in a well ventilated place, preferably outdoors. The burning sulphur should be in an enclosed chamber and the gas should not be breathed in. Sulphite solution should be kept away from the skin as it can cause a rash.

The method for preparing a sulphur dioxide concentration is described in the section on drying in Book Two.

Description of processing methods for fruit and vegetables

Drying

Drying is one of the most widespread food processing methods used to preserve foods. It involves reducing the amount of water in fruit and vegetables to a low enough level so that the spoilage *enzymes* and bacteria cannot work.

Drying has three main purposes:

- **to prevent or inhibit micro-organisms and spoilage enzymes**
- **increase shelf-life**
- **to reduce the weight of food for cheaper and more convenient transport and storage**

Dried fruit and vegetables have a fairly long *shelf life*, provided they are packaged well and stored in a dry place.

When foods are dried correctly, the nutritional quality, colour, flavour and texture of re-hydrated foods are only slightly less than fresh food. However, if *drying* is not carried out properly there is a greater loss of nutritional and eating qualities and more seriously, a risk of microbial spoilage and possibly even food poisoning.

The stability of a dried food during storage depends on its moisture content and the ease with which the food can pick up moisture from the air. The risk of moisture pick up is greater in regions of high *humidity*. Dried foods must be stored in moisture-proof packaging to prevent them absorbing water from the surrounding air.

Box 5: Factors that affect the rate of drying

- Temperature - of the outside air and inside the dryer
- Humidity of air
- Speed of air flow throughout the dryer
- Type of fruit or vegetable (the amount of water to be lost and the level of sugars in the fruit)
- Size of the fruit or vegetable pieces
- Loading rate of the dryer (the amount of fruit/vegetable per

Box 6: The basics of drying

Drying involves removing water from the food product into the surrounding air.

For effective drying, air should be hot, dry and moving. These factors are inter-related and it is important that each factor is correct:

- air must be dry, so it can absorb the moisture from the fruits and vegetables
- heating the air around the product causes it to dry more quickly
- if the air is not moving across the food, it cannot get rid of the water vapour that it has collected. A fan or air blower is needed to keep the air circulating.

In summary - when food is dried, hot dry air comes into contact with the food. The hot air absorbs water from the food and is moved away from the food. New dry air takes its place and the process continues until the food has lost all its water.

Sun drying

Drying fruit and vegetables in the sun is simple and requires very little equipment. The fruit is spread on a flat surface, such as a mat, open roof or metal sheet, and left to dry naturally in the sun. However, there are several disadvantages of using this method. Table 6 summarises the advantages and disadvantages of sun *drying*:

Table 6: Advantages and disadvantages of sun drying

Sun drying of fruit and vegetables	
Advantages	**Disadvantages**
• Very little equipment is required • Almost without cost • Ideal for products where little or no value is added • Food is usually dried close to the home	• Open to contamination by dust • Totally dependent on good weather • Very slow drying rates with danger of mould growth in humid areas • It may not be possible to dry to a sufficiently low level of moisture to prevent mould growth

There are several simple steps that can be taken to make sure sun-dried fruit and vegetables are of the best quality possible:

- Keep them clean while they are *drying*
- Use mesh trays that are lifted off the floor
- Clean the trays regularly
- Cover with mesh or netting to prevent insects landing on the fruit
- Keep animals away from the products while they are *drying*.

Sun *drying* is good for low value products, but for high value fruits and vegetables, it is better to use a *solar dryer* or simple cabinet dryer.

Figure 12: Apricots drying
© Practical Action

Solar drying

Solar drying also makes use of the heat energy from the sun. It involves the building of a simple structure that collects and enhances the heat from the sun (this is known as the collector). There is also a *drying* chamber that the fruit is placed in for *drying*.

Solar dryers have several advantages over sun *drying*:

- They generate a higher air temperature and lower *humidity* which results in a shorter *drying* time and lower final moisture content of the dried product.
- The higher temperature deters insects and mould growth.
- The product is protected from dust and insects within the dryer.
- *Drying* is quicker.
- If stacking racks are used, less land space is needed for spreading out the crop.
- The *drying* products have some protection from rain.
- *Solar dryers* are comparatively cheap to build and do not require skilled labour.

There are two basic types of *solar dryer* - direct and indirect

Direct solar dryers

In a direct *solar dryer*, air is heated in the *drying* chamber which acts as both the solar collector and the dryer. The best known type of direct *solar dryer* is the Brace Dryer. A simpler type of dryer is the tent dryer. *These dryers are described in Annex 2.*

Figure 13: A tent dryer

Indirect solar dryers

An indirect *solar dryer* has two parts – a solar **collector** that receives the sun's radiation and a *drying* **chamber** in which the fruit or vegetable is placed. The collector is connected to the *drying* chamber. Air enters the collector where it is heated, its *humidity* is reduced and the hot air naturally rises to the *drying* chamber.

The main advantage of the indirect *solar dryer* is that the product being dried is away from the direct sunlight. This helps to prevent loss of colour and vitamins during *drying*. However, indirect dryers are more complicated and more costly to build than direct dryers and should only be used for high-value products with a market that demands a high quality product.

Which type of dryer to choose?

The design of either type of dryer (direct or indirect) must be adapted to suit local climatic conditions, the products to be dried and available construction materials.

Factors to consider when selecting a dryer are described in box 7 below.

Shading from the direct sun

Box 7: Factors to consider when selecting a dryer

- **Local climate – is it wet or dry.** How many hours of sunshine are there in a day? In Afghanistan, the climate is generally dry and there is a lot of sunshine, such that sun and *solar drying* are easy to do.
- **The availability (and cost) of materials to build a dryer.** This is linked to the end-use of your fruit and vegetable. If you can sell the product for a good price, it may be worth investing in a slightly more expensive dryer. Can you join together with other women who will use the dryer? You could all contribute to the building costs of the dryer and make a good dryer that will be well used by your community.
- **The availability of local craftsmen or workmen to build a dryer.** You will need somebody to follow basic plans and construct the dryer. It is useful if they understand how the dryer works as they will be able to adapt the plans to your local conditions and advise you on how to use it.
- **The amount of fruit and vegetables you want to dry.** If you have a large volume of fruit and vegetables to dry, it is best to build several small dryers that can be used at the same time, rather than trying to make a big dryer that will accommodate all your product. That way you have more control over the *drying* conditions and will get a better quality product. If any of the dryers are broken, for instance if the plastic cover gets damaged, you will still have others that you (and your neighbours) can use. You can dry more than one product at the same time.
- **The value of the fruit or vegetable you are *drying*.** Is it a high value product that you will be able to sell for a good price or is it a low value product that you will consume at home? This will help you to decide how much money you can afford to invest in buying a dryer.

Some vegetables, especially the green ones, are damaged by sunlight. If they are dried in direct sunlight they become dark and the vitamins are destroyed. It is best to dry them in the shade or to hang some dark screens inside the dryer to act as sun shades. The screens can be made from black-painted roofing sheets.

Some dryers, particularly the indirect type, incorporate large amounts of dark coloured rocks in the collector. When the rocks have been heated in the sun all day, they continue to give off heat after nightfall and the produce continues to dry without being exposed to direct sunlight.

Jam-making

Jams are made by a combination of food processes – *boiling* to reduce the water content and to kill *micro-organisms* and spoilage *enzymes*, combined with the addition of sugar and *acid* to prevent the growth of *yeasts* and *fungus* after the *jam* has been made. If they are properly made and stored in a cool place away from direct sunlight, *jams* have a *shelf life* of several months.

Sugar is added to fruits as a preservative. Sugar binds with the water in the fruit or vegetable and makes it unavailable for the bacteria to use. Therefore, the growth of bacteria is halted. However, after some time, *yeasts* and *fungi* may start to grow on the fruit preserve, especially if they are packaged into dirty containers or are contaminated after opening.

Making *jam* is a scientific process. It requires the correct amounts of fruit, sugar, *acid* and *pectin* to make a good product with a long *shelf life*. Table 7, below, lists the ingredients needed and their role in *jam* making.

Figure 14: Making fruit jam

Table 7: Role of ingredients in jam-making.

Warning! At first glance, the idea of making *jam* or *jelly* is quite attractive as

Ingredient needed	Purpose
Sugar	Is a preservative. The *jam* should have a final sugar content of 65 to 68% to ensure that the fruit is well preserved and safe from bacterial spoilage. All fruits contain natural sugar (between 10 and 12%).
Pectin	Forms a strong gel in the *jam*. Some fruits contain high levels of *pectin* and do not need any adding. Other fruits have low levels and need to be mixed with high-*pectin* fruits such as apple or banana, or commercial *pectin* must be added to make a good set *jam*.
Acid	Helps to form a strong gel and gives the *jam* a good flavour. The optimum *pH* for *jam* is 3.0-3.3. Some fruits are *acidic* but others need to have *acid* added to reach this *pH* . Lemon juice (citric *acid*) is usually added to the fruit to increase the *acidity*. Unripe fruits can be added as they are more *acidic*.
Fruit	Should be ripe and of good quality. Under-ripe fruit can be added as this is more acidic. Over-ripe fruit should not be used as the pectin content is low.

the process appears to be quite simple. However, it must be stressed that *jam* should **ONLY** be made if there is a guaranteed market for it, not just to use up a surplus of fruit. Too often *jam* is made for this reason and then sits in the store room of the processor or NGO where it spoils.

Chutneys, sauce, ketchup, and paste

A range of fruits and vegetables can be used to make sauce, ketchup and chutney. The basic principles of the preservation method are the addition of salt or sugar and *acid* (*acetic acid* or vinegar) combined with *concentration* of the mixture by heating to reduce the water content.

Chutneys

Chutneys are thick, *jam*-like mixtures that are made from a variety of fruit and vegetables, with added vinegar, salt or sugar and spices. The mixture is heated to reduce the moisture content. Any edible sour fruit or vegetable can be used to make chutney.

Vinegar and sugar are often quite expensive ingredients, which make the chutney expensive to make. Sometimes it can be more cost effective to make the atchar types of pickle that are made by adding salt to vegetables and allowing them to ferment (see section on pickles below).

Sauces, ketchup and pastes

Sauces and purees are similar to chutneys. They are made from a mixture of fruit, vegetables, spices, salt, vinegar and sugar which are heated to evaporate water and to concentrate the mixture. Sauces are thinner than chutneys and tend to be more acidic. If sauces and purees are heated further to remove more water, they can be made into paste.

Fermented pickles (“atchar” or “toorchi”)

Figure 15: Tomato paste

Fermented *pickles* (atchars) are made by adding salt to vegetables (or fruit) and leaving them to ferment for a few days. During *fermentation*, *lactic acid* is produced which reduces the *pH* of the product and helps to preserve it by preventing the growth of spoilage bacteria.

Pickles can be stored for several months when they are kept in a cool dry place, away from direct sunlight.

Figure 16: Pickles

Acetic acid (vinegar) is often added to a fermented pickle to increase the acidity (reduce the *pH*) so that it is optimum for the *lactic acid* bacteria. This will speed up the *fermentation*. The *acetic acid* of the vinegar reduces the *pH* of the pickle, thereby improving preservation and giving it a distinctive taste.

Wild mustard seeds ("*awri*") are also often added to the vegetables with salt or *brine* (instead of vinegar).

Fermented pickles – process requirements

The basic requirements for a fermented pickle are vegetables, salt and a small amount of juice left over from a previous pickle *fermentation* (a *starter culture* –see box 8 below). Salt provides the perfect conditions for the *lactic acid* bacteria to grow. As they grow, the bacteria produce *lactic acid* which reduces the *pH* of the pickle and gives it its distinctive taste. Salt is either added to the vegetables as dry salt or made into a *brine* in which the vegetables are soaked.

Dry salted pickles

Salt and vegetables are mixed together in a container that is suitable for *fermentation*. You need 1kg salt for each 30kg vegetables. Place alternate layers of vegetables (about 2.5cm deep) and salt in the *fermentation* container until it is about three quarters full. Cover with a cloth that is weighted down to help with the formation of *brine*. The salt extracts juice from the vegetables and eventually creates a *brine*. As soon as the *brine* is formed, *fermentation* starts and bubbles of carbon dioxide gas appear.

Brine pickles

Figure 17: Salt being poured into a bucket for pickle-making

Brine (a solution of salt dissolved in water) is used for vegetables that are naturally low in water. Make a 15-20% salt solution by dissolving salt in water (see the section on preparing solutions in Book 2 for advice on how to prepare a *brine*). Place the vegetables in the *brine* and use weights (for example, clean plates) to hold them under the solution. Seal the container and leave to ferment. The strong *brine* draws sugar and water out of the vegetables, which decreases the salt *concentration* of the *brine*. It is important that the salt *concentration* does not fall below 12% as *fermentation* will not be able to take place. Add extra salt to the fermenting bucket to maintain the strength of *brine*.

Box 8: Fermented pickle - Starter culture

A *starter culture* is added to fermented pickle to speed up the *fermentation*. If the *fermentation* takes too long to start, other (poisonous) bacteria may start to grow instead of the lactic acid bacteria.

A *starter culture* is a solution containing the Lactobacillus bacteria that are needed to do a *lactic* acid *fermentation*. It is usually a portion of fermented pickle juice that is left over from a previous *fermentation*. Some pickles will naturally ferment because the bacteria are present in the air and on the vegetables. You just need to give them the right conditions to get started - -warmth and salt.

The use of oil in pickle making

Vegetable oil is added to some types of pickle, especially the fermented *pickles*. It can be mixed with the spices to make a paste to add during preparation, or poured onto the top of *pickles* after they have been bottled to form a barrier against oxygen. This practice is not so common in Afghanistan due to the prohibitive cost of oil, and low quality of available oil.

Only good quality vegetable oil should be used. Old oil will have a bad taste and can spoil the taste of the pickle. Different oils have their own individual tastes and give the pickle a different taste. In some countries mustard oil is used – this has a very strong flavour and aroma and may not be liked by some consumers. Sunflower oil is the best oil to use for pickle making as it does not have a strong taste or aroma.

Figure 18: Oil

Vinegar

Vinegar is also known as *acetic acid*. It is one of the by-products made when bacteria ferment fruit and vegetables. Because vinegar is acidic, it can also be used to preserve fruit and vegetables, in particular when making *pickles*.

The production of vinegar is a two stage process. First the starch or sugar present in fruit and vegetables is turned into ethanol by adding yeast which ferment it. This is an anaerobic *fermentation*, which means it should be carried out without any oxygen. The second stage of the process is the oxidation of ethanol to form *acetic acid*. In this stage, oxygen is needed to turn the ethanol into *acetic acid*.

A number of different fruit and vegetables can be used to make vinegar – grape, apple, berries. Vinegar can also be made by utilising fruit waste, for example tomato peel and seeds, fruit peelings.
The strength of the finished product is in direct proportion to the amount of sugar in the original solution. For this reason sweet fruits usually make stronger vinegar than sour ones although this is not always so. Some sour apples actually have a high proportion of sugar which is masked by a high fruit *acid* content. If you are using your own vinegar to make *pickles*, you need to make sure that it is strong enough to preserve the pickle. A vinegar for pickling should have 5% *acetic acid*. If your vinegar is not as strong as this, your *pickles* will not store for very long. You can test the strength of your own vinegar by doing a simple *titration* (see last section of Book Two for more details).

Tips for assuring quality when processing foods

Whatever type of preservation technique is used, there are several basic principles of good practice that should be followed to improve the hygiene and quality of the products. Table 8 below summarises the key points that will help in preparing a good product.

Table 8: Best practices to ensure high quality products

Process	Equipment required	*Best practice to ensure a high quality product*
Selection of raw material		Only good quality fruits and vegetables should be used for processing. Any damaged or bruised parts should be cut out and thrown away. Do not use over-ripe fruit especially for *jam* making as the *jam* will not set.
Cleaning	Plastic buckets, sink, drainer *Chlorine* or bleach Water	All fruit and vegetables must be washed to remove dirt and traces of pesticide. Clean water is essential. Water can be chlorinated using bleach or *chlorine* – plastic buckets are needed for mixing the bleach with water. Drain the water, especially if the fruit is being stored.
Cutting, chopping, peeling	Stainless steel knife, plastic chopping board	Stainless steel knives are the best type to use as they do not stain the flesh of fruit and vegetables. However, stainless steel knives are expensive and probably not available in all homes. Always use a sharp clean knife that is only used for cutting fruit and vegetables. Do not use a knife with a rusty blade or a knife that is also used to cut meat. Plastic chopping boards are best as they can be washed in hot water or boiled to sterilise. Wooden chopping boards are not good as they are difficult to clean (juice from the fruit and vegetables can get into the wood). Make sure you use a clean flat surface that can easily be washed and is away from flies and other contaminating products. For example, do not cut strong smelling vegetables such as onions or garlic in the same place as fruits – the taste of onion will contaminate the fruit. Do not cut meats and fruit and vegetables at the same time. Peel and chop the fruit in small batches so that they are not left for a long time before the next stage of the process. Once they are chopped, the fruit and vegetables are susceptible to bacterial contamination and spoilage. Store the chopped fruit and vegetable in a pan of clean cold water to prevent them browning and deteriorating. Salt can be added to the water to kill any insects. Citric *acid* (lemon juice) can be added to the water to prevent fruit such as apples from browning.

Process	Equipment required	*Best practice to ensure a high quality product*
Heating (including *pasteurisation*)	Large pan, thermometer, controllable heat source	A large heat resistant pan is needed for several food processes. It can be used to make *jam*, some *pickles* and chutneys. It can also be used to boil water which is used for *blanching* vegetables and for pasteurising *pickles* and chutneys. A thermometer is needed to check the temperature, especially when pasteurising. It is useful for *jam* making, but not essential (alternative methods can be used to test when a *jam* is cooked). A controllable heat source is preferred so that heating can be adjusted.
Weighing and measuring	Weighing scales, cups, spoons, measuring jug or bottle	It is important to add the correct amount of ingredients to preserve the product well and to ensure consistency between different batches. If weighing scales are not available, cups or tins that are found in the house should be used. They should be labelled and marked with the quantities. Remember that different materials (sugar, *pectin*) will not weigh the same amount. Bottles or jars of a known volume can be used to measure out ingredients.
Mixing	Plastic bowls and spoons	Plastic bowls are better to use than metal ones, especially for acidic fruit products. Plastic spoons are better than wooden spoons as they are easier to clean.

Part 4 Post Processing Packaging and Storage

Packaging is an essential part of all food processing operations. Good and appropriate packaging will ensure that your processed products do not become spoiled and remain edible for as long as possible.

The purpose of packaging

The main reasons for packaging food are:

- To protect the product from spoilage by preventing moisture and air from entering the product (or, in the case of fresh produce, to prevent moisture from escaping from the fruit and vegetable)
- To protect the product from dust, dirt, and contamination from *micro-organisms* and consumers who handle the products
- To prevent the loss or leakage of products
- To make transport of the product easier
- To keep the product in good condition until it is sold and consumed
- To make the product look attractive and encourage consumers to purchase it.

Types of packaging available

The main types of packaging are as follows:

- Glass bottles and jars
- Plastic bottles and jars
- Paper wrappers
- Bags and sacks
- Earthenware pots
- Plastic films
- Cans

Figure 19: Types of packaging – glass bottles, plastic jars, plastic bags

Each type of packaging has different uses and is suitable for a different product or under certain conditions. Table 9 summarises the advantages and disadvantages of each type and the products they are most suited for.

Table 9. Advantages and disadvantages of different packaging materials

Material	Advantages	Disadvantages	Product suitability
Glass	Can be heat treated to sterilise Provides a good barrier against air, moisture, odours and *micro-organisms* Strong and rigid so protects the contents Can be re-used See-through so the contents can be seen	Heavy - which increases transport costs Breakable, which could be dangerous if broken glass gets into the product Expensive Not easily available in Afghanistan	*Pickles*, chutney, *jams*, juice
Plastic bottles	Lighter than glass Not breakable Lower cost than glass	Cannot be sterilised Cannot be re-used	Pickles, chutney, jams
Plastic films	Relatively low cost Good barrier protection against moisture and air Heat sealable Strong Light so do not add weight to the product	Some thinner films allow air and other gases and odours through	Fruit leather, dried fruits
Paper wrappers and bags	Cheap and readily available Lightweight	No protection against moisture or air Easily torn Not very attractive	Fresh produce with a short shelf life
Sacks **(vegetable fibres)**	Strong and flexible Lightweight Readily available Biodegradable	No protection against moisture or air No protection against rodents Rot easily	Fresh produce
Cans	Strong and unbreakable Good barrier to air, moisture and odours Good barrier to rodents and insects	Expensive to can products at the small scale	*Jams*, fruit in syrup, canned fruit and vegetables

Note on hygiene of recycled glass bottles and jars:
It is often very difficult and expensive for small scale processors to obtain supplies of new glass bottles. Therefore they use recycled glass bottles that are cleaned and sterilised before use. It is important to clean and sterilise bottles adequately before they are used for food products. Also, new lids and caps should be used as it is not possible to get a good seal with old lids and caps. It is important not to use glass bottles that have been used for storing non-edible products such as oil or kerosene.

Note on the hygiene of plastic jars and bottles:
Plastic bottles and jars cannot be sterilised to clean them as they do not withstand high temperature heat treatment. It is essential that you use clean bottles and jars for all food products or you will contaminate the product and it will have a short *shelf life*. Make sure that the bottles you use are washed using chlorinated water and that they are turned upside down to drain before they are filled. Under no circumstances should they be dried with cloths as this can contaminate them.

Part 5 Hygiene and Food Safety

Keeping foods clean and hygienic throughout the process

It is important to stress that one of the most crucial parts of food processing is **hygiene** and attention to cleanliness at all stages of the food chain.

How can bacteria be introduced into fruit and vegetables?

When fruit and vegetables are harvested, they are generally in good condition and safe. The outer skin of the fruit or vegetable may be dusty or dirty, but inside the skin is a clean fruit or vegetable that is safe to eat.

Bacteria that cause spoilage generally get into fruit and vegetables when the skin is damaged or intentionally broken. Occasionally insects lay eggs inside the fruit while it is at the bud stage and the larvae hatch from inside –this is common with apples, where grubs or maggots can incubate inside the fruit, hatch out when they are mature and cause spoilage from the inside.

In hot climates, fruit and vegetables may start to ferment if they are left for any length of time.

Peeling, slicing and chopping all expose the inside flesh of fruit and vegetables to the exterior air and also to potential sources of contamination.

The following rules explain how to prevent contaminating foods during food processing.

Simple hygiene rules to protect foods during processing

Processing room

- Keep the building **clean** and **tidy** at all times.
- **Do not** let **animals** into the room.
- Keep out **insects** and **pests.**
- **Toilets** must be in a **separate** room.
- Store the **raw materials** in a **separate** room or cupboard.
- Keep the **cleaning materials** in a **separate** room or cupboard.
- Store the **finished products** in a **separate** room.
- The **store** room must be in a **cool dry** place away from the direct sunlight.
- Only use **clean** water to wash equipment

Figure 20. Which room would you rather be processing foods in?

Equipment

- Only use equipment that is **suitable** for food use.
- Do **not** use **painted** equipment.
- Do **not** use **rusty, dirty** or **broken** equipment.
- Take **care** with **glass** – it can break and get into the food.
- **Clean** the equipment every day as soon as it has been used.
- Make sure the knives you use are clean.
- Protect the equipment from flies and dust. Note that flies are very attracted to the sweet juice that fruits contain and which coat the knife and the cutting board, so make sure you wash the knives and other equipment between each use.

> **Clean water**
> Boil dirty water for 10 minutes to remove bacteria. Only use this for washing equipment, not for processing food.
>
> Clean water for processing by adding *chlorine* (see section on chlorination in Book Two).

Figure 21: Which equipment would you prefer to use?

Personal hygiene

> **Dirt spreads diseases.**
>
> **Wash your hands, tools and work surfaces.**

- Do **not** handle foods if you are **ill.**
- Always wear **clean aprons** and **gloves.**
- Tie back long hair and cover with a **hat or clean scarf.**
- **Cover cuts** and **wounds** with a clean waterproof dressing.
- **Wash** your hands.
- Do not **smoke.**
- Do not **eat.**
- Do not **spit, cough** or **sneeze** over foods.

Figure 22: Which person would you buy processed foods from?

Food handling

Minimise the time between peeling and chopping and the next stage of the operation. If the peeled fruit and vegetables have to wait around for any length of time, make sure they are covered to prevent contamination. Make sure you prepare and store the fruit and vegetables in a shaded place and keep them cool.

Packaging and storage

- Keep **raw materials** away from **processed** food.
- **Cover** all foods to protect them from **flies, rats, mice** and other creatures.
- Use **clean undamaged packaging** material for the products.
- **Label** all foods **clearly,** specifying the product content and date of processing.

Annex 1

Storage structures

After harvest, it is important to reduce the temperature of fruit and vegetables and store them in a cool place to keep them fresh for as long as possible. At high temperatures the rate of respiration of fruit and vegetables is high. Moisture is lost from the fresh produce which causes them to wilt and lose shape and quality. If you reduce the temperature by 10°C, the length of time that the produce remains fresh will double.

Storage structures for warm climates

In warm climates, it is important to store harvested produce in a cool place. Evaporative cooling is a simple method that can be used to make a cool storage chamber.

How to make a simple evaporative cooling chamber

Materials needed

Building material suitable to build a chamber – bricks, sand, stones
Lengths of wood, or metal
Sacks or cloths
Source of water

Construction method

1. Build a floor from a single layer of bricks.
2. Build the walls with a double layer of bricks. Leave a gap of about 10cm between the two walls.
3. Fill the cavity between the two walls with sand.
4. Make a cover for the top of the chamber by placing wooden beams across the chamber and putting sacks on them.
5. Make a roof or shelter to cover the whole storage chamber so that it is in the shade.
6. Soak the walls, floor, sand between the walls and the cover with plenty of water until the whole structure is saturated.
7. Wet the whole structure twice a day (or more in hot, dry climates) to make sure it is always saturated with water.

To build a chamber that can store about 100kg of fruit and vegetables, you need about 400 bricks. The storage structure should be built in a place where the breeze blows to help evaporate the water and cause cooling.

How to make an evaporative pot cooler

An evaporative pot cooler is a smaller version of the cool chamber that is ideal for use by the household. It can easily be constructed using clay pots. There are several designs for the pot cooler, it depends on what materials are available locally

The pot-in-pot cooler

Materials needed

Two clay pots, one smaller than the other so it fits inside the large one. (Note: you can use two *tandoors* of different sizes)
Sand

Construction method

Place sand in the bottom of the larger clay pot. Sit the small pot inside the large one and fill the space between the two with sand or earth.
Soak the whole structure in water, then place in the breeze so that the wind causes the water to evaporate. The evaporation causes the inside of the pot to cool down.

Place fruit and vegetables inside the pot and cover with a wet muslin cloth.

Figure 23. Example of a pot-in-pot cooler

The Janata cooler

The Janata cooler is another type of evaporative cooler. It can easily be made at home, using locally available materials.

Materials needed

Clay bowl
Clay storage pot
Old cloths
Sand

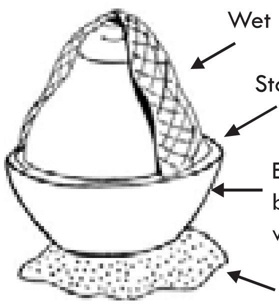


Figure 24: A Janata cooler
© Practical Action Technical Brief

Preparation Method

Take a large earthenware bowl and fill it with water.
Stand the bowl on a mound of wet sand.
Stand the storage pot in the bowl of water and cover with a wet cloth.
Water evaporates from the pots, cooling down the fruit and vegetables within the cooling pot. Keep the pot wet so that it can continue to evaporate and provide constant cooling.

Storage structures for use in cold climates

In cold climates, there is often a problem with the temperature falling too low, especially at night time. The stored fruit and vegetables can be damaged by frost and low temperatures. Fruit and vegetables that contain a high percentage of water (for example, potatoes, cucumbers, green leafy vegetables and, tomatoes) are all particularly vulnerable to damage by freezing.

In climates such as this it is important to insulate the store chamber. Straw, sacks and old cloths are all used to insulate storage chambers.

Storage clamps are traditionally used for the storage of potatoes and other root vegetables such as turnips and carrots.

How to make a storage clamp

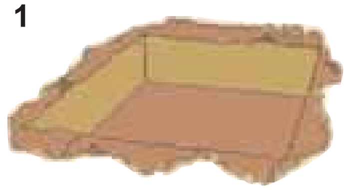
Materials needed

A patch of land
Straw or similar insulation material

Construction method

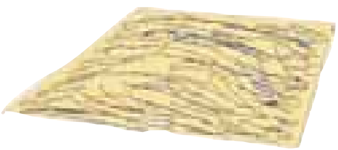
1. Clear a patch of earth and dig a shallow trench (about 10cm/4 inches down), the area it takes up is dependent on how much you need to store.

1



2. Fill the base of the trench with straw and pile up the clean, undamaged potatoes into a pyramid shape. The potatoes should be piled up to half the width of your clamp. So, if the clamp is 1 metre wide, the pile should be a maximum of 50cm tall.

1a



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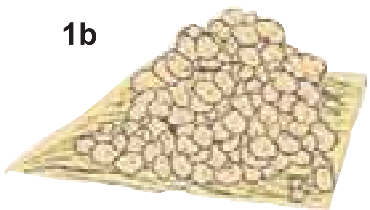
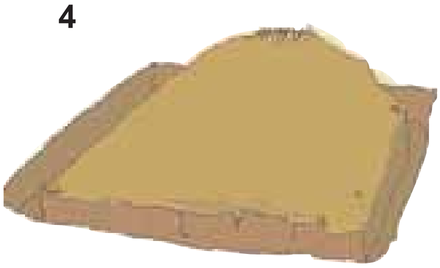


3. Cover the pile of produce with another layer of straw, about 15cm (6 inches) thick.

3

4. Cover the pile of straw covered potatoes in a layer of earth (15cm thick) and dig a trench around the base of the clamp.

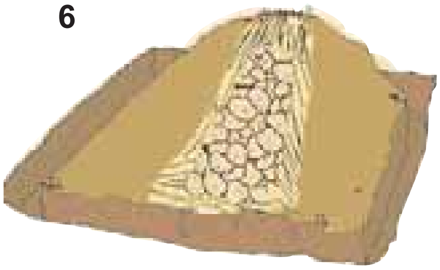
4



5

5. Make a small ventilation hole (about 6cm in diameter) in the top of the earth pile and fill it with straw.

6



6. This is a cross section through the finished clamp. If good quality potatoes are put into the clamp, they should be stored over the winter months

Figure 25.1 to 25.6: Different steps in making a potato clamp

Ref: http://www.selfsufficientish.com/clamp.htm

A field storage clamp for potatoes

A field storage clamp is a low cost technology that can be designed using locally available materials for ventilation and insulation.

Materials needed

Wood to make a ventilation box
Straw for insulation

Construction method

To reduce heat gain, the field clamp should be built in the shade (e.g. under a tree or on the cool side of a building).

1 Construct a ventilation box with the wood, in the form of a triangle. It should be the length of the planned storage clamp (see Figure 26, below).

2 Pile the potatoes over the ventilator to create a triangular heap of potatoes. The size of the pile is determined by the amount of potatoes you have to store and by the local climate:
- If it is cold, the width of the pile should be at least 1m and can be up to 3m at the base. The more potatoes there are in the store, the more they will help to insulate each other.
- If it is hot, the maximum width should be 1.5m (this is to prevent the build up of too much heat within the store).

The length of the pile should be about 1/3 to ½ of the width of the pile.

3 Cover the pile of potatoes with straw and a layer of soil, which is loosely compacted.
- In very cold regions, a second layer of straw and soil can be added.
- In hot regions, less soil is needed, but more ventilation can be added by constructing chimney type air outlets at the top of the clamp.

4 Dig a drainage ditch around the clamp to avoid water accumulating at the base.

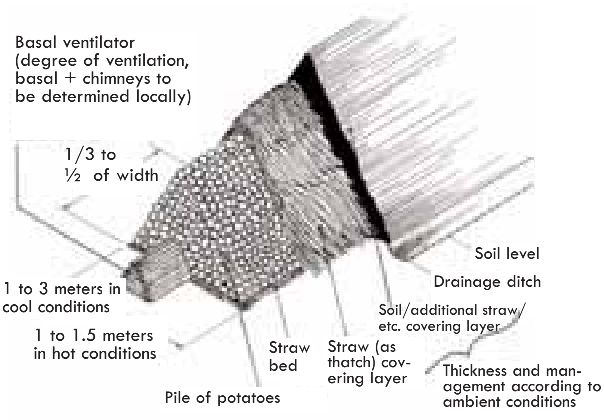


Figure 26: Building a potato clamp (CIP, 1981).

Storage house for potatoes

Simple storage houses for potatoes can be constructed for small quantities of produce. They can be made from mud bricks or stones that are covered with wooden lath and plaster. The following example, of a cylindrical house, has been used in the Andes Mountains in Peru.

Materials needed

Bricks, stones or mud bricks
Wood laths
Plaster
Straw thatch for the roof

Construction Method

1 Build the cylindrical storage house out of bricks. In very cold places, it may be possible to build a double-walled cylindrical chamber with a gap that can be filled with insulating material such as straw or sand.

2 Place two doors in the storage house:
- One door on top for loading potatoes inside
- One door at the bottom for easy removal of potatoes.

3 You can paint the store house white to reduce heat accumulation.

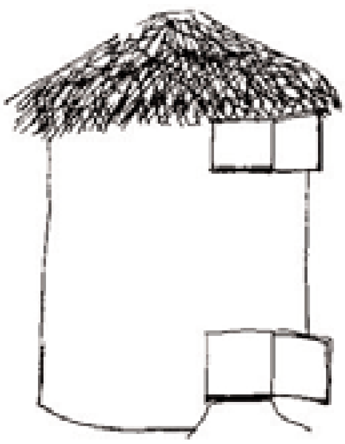


Figure 27: A cylindrical potato storage house.

4 Place a thatched roof on the top to protect the potatoes from rain, snow and sun.

Annex 2
Solar Dryers

Several types of dryers can be constructed. The choice of dryer will depend on a number of factors described in the section on drying of the manual (see box 7) of the manual.
When building a dryer, you should also consider a number of factors described in box 9 below.

Box 9: Factors to consider when building a dryer

Shading from the direct sun
Some vegetables, especially the green ones, are damaged by sunlight. If they are dried in direct sunlight they become dark and the vitamins are destroyed. It is best to dry them in the shade or to put some dark screens inside the dryer to act as sun shades.

The position of the dryer is critical
The collector has to be positioned at the correct angle to the sun so that it collects the maximum amount of sunlight. The angle of the sun's rays varies between summer and winter, so when building a dryer, you need to consider the time of year when the fruit or vegetable is harvested:

- The angle of the lid of the dryer should be greater than 15° so that rain water will run off
- The collector should be angled at 90° to the mid-day sun so it collects the maximum amount of rays
- The collector should face south in the northern hemisphere and north in the southern hemisphere
- The collector should be sited away from shadows, trees and buildings.

The type of plastic to use
Special plastic sheeting for use in solar dryers is not available at the village-level but polythene is generally found in towns. Polythene has a short life in solar dryers as it turns yellow and tears easily. You need to replace it when it turns yellow or cloudy as this prevents light getting through. It is best to make the collector cover in several small sections so that if damage occurs only one small piece will need replacing.

Tent dryer

The tent dryer is a simple type of direct *solar dryer* that is cheap and easy to build. It consists of a frame of wooden poles covered with plastic sheeting. Black plastic should be used on the wall facing away from the sun. The food to be dried is placed on a rack above the ground. Tent dryers provide protection against rain, insects and dust. They can easily be taken down and stored when they are not in use.

Materials needed

For the dryer:
- 4 wooden beams 1.5 – 2.0m long (for the long top beam and bottom beams, plus extra support midway along the back side)
- 4 wooden beams 1.3m long (for the sides)
- Black polythene (plastic sheeting) to cover the back panel and the floor
- Clear polythene (plastic sheeting) to cover the front and sides of the framework

Note on polythene (plastic sheeting): polythene is cheap and easily available in most places. However, polythene turns yellow and opaque after a few months use and needs to be replaced.

For the *drying* platform:
- 4 legs at 20 cm height.
- 4 lengths of wood (80cm long)
- Wire mesh (non-corrosive) or woven thin lengths of wood or stems; to cover the platform

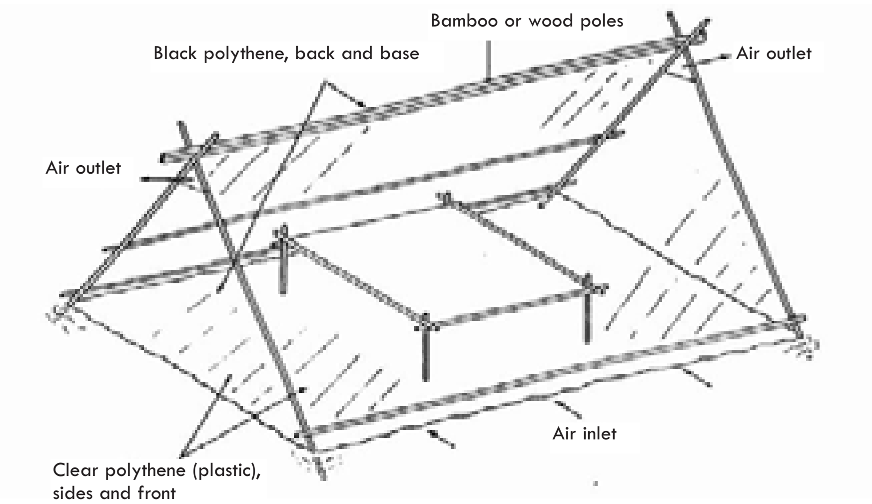


Figure 28: A typical tent dyer

Annexes

Construction method

Assembling the tent:

1. Assemble the wooden beams as illustrated in the figure 28 above. The side beams (1.3 m long) should be buried in the ground at their base, and should overlap so as to cross each other at the top.
2. Fix the black plastic sheeting on the back side of the dryer and on the ground.
3. Fix the clear plastic sheeting on the front side of the dryer (facing the sun), and on the side.

   If you do not have any ventilation in the dryer, condensation will build up and the produce will not dry. For this reason, it is essential to leave space for the air to enter and leave the *drying* chamber, by:
   - cutting air exit holes at the top of the triangle side panels
   - attaching the plastic sheet covering the front panel to a bottom rail that is about 10cm above the ground level. This rail can be rolled up to allow easy access to the chamber, to put the *drying* platform inside and place fruit inside.

Assembling the *drying* platform:

1. Assemble the legs and wooden frame
2. Place a wire mesh, or thin lengths of wood assembled to make a net-like structure, on the wooden frame. The holes in the mesh or between the wood should not be too small to ensure that produce do not fall through them. They should be large enough to ensure that the air circulates around the produce.

Note on wind

In very windy locations, tent dryers can be damaged by the wind: the plastic can be torn, the frame can break or fall. You should therefore position the tent dryer so that it is protected from strong gusts of wind.

If this is not possible, you should choose a different type of dryer, such as the one described below in figure 29. This dryer has mud walls and ventilation holes that are covered with wire mesh. The structure is covered with polythene. This structure is more stable than the lightweight tent dryer and can withstand more harsh and windy conditions.

You can also use the Brace cabinet dryer or mud *solar dryers* described below.

Figure 29: A type of solar dryer, made with mud walls.

Brace cabinet dryer

Brace dryers can get to a higher temperature than a tent dryer so have shorter *drying* times and therefore produce a higher quality product.

A Brace *solar dryer* consists of a wooden box with a hinged transparent lid, made from plastic sheeting, polythene or glass. Radiation from the sun passes through the lid of the dryer and heats the dryer chamber, which is painted black so that it absorbs the maximum amount of heat. The heated air rises and leaves the chamber through exit holes in the upper part of the back wall. It is replaced by cold air that enters though the holes in the base of the dryer. This sets up an air flow system which removes the moisture from the product. The food to be dried is placed on a mesh tray above the dryer floor.

The size and site of the dryer depends on the use of the dryer and the availability of materials. As a general guide, the dryer should be about 2m long by 1m deep. The back wall should be about 45cm high and the front wall about 25 cm high.
However, the dimensions of the dryer are likely to be limited by the size of the polythene that is available for the cover. Buy the polythene first and make your frame to fit the cover.
The dryer should be built at a height that is easy to work with and that allows the air to circulate under the dryer – e.g. about 1 metre off the floor.

Materials needed

4 sturdy wooden poles (1.5m long) (that act as legs to which the frame is attached)
2 long poles (2m long and about 6 to 7 cm wide) for the base of the back and front walls
2 long poles (1m long and about 6 to 7 cm wide) for the base of the side walls
Woven matting or thin planks of wood for the walls – you can use reed or woven mats that are used as bedding mats Each wall is composed of two mats with a 5 cm gap in between them, that should be filled with insulation material. You will need:

- 4 side pieces (1m x 45cm)
- 2 back panels (2m x 45cm)
- 2 front panels (2m x 25cm)

Insulation material – burnt husks that are tightly packed in the gap between the walls
Clay or mud to coat the walls and make the structure more sturdy.
Non-corrosive wire mesh or woven sticks of wood or stem, and wood sticks (15-20 cm for the legs) to make the *drying* platform
Plastic/polythene sheeting to make a roll-down lid
Four wooden batons on which to attach the polythene sheeting

Construction method

Construct the wooden frame.

Attach the woven matting side walls. Cut the matting for the side panels so that it is 25cm at the front of the dryer and 45cm tall at the back. Leave a 5cm gap between the walls. Fill the gaps with an insulation material (use the burnt husk of cereals or other material).

Make ventilation holes in the bottom edge of the front wall and in the upper edge of the back wall.

Cover the whole structure with a mixture of clay or mud, both inside and out. Let the clay dry (but leaving the holes open)

Construct the drying platform:

The *drying* platform is made using sticks for legs and a woven top surface. For maximum use of the dryer, the platform should fill the interior of the cabinet. The top of the platform should be about 5- 10cm below the top of the front wall of the dryer to prevent the sides from shading the food while it is *drying*. You can make one big *drying* platform or two or three smaller platforms that fit inside the dryer. This depends on the size of your dryer and the ease of use (it is easier to handle smaller units than one large platform). The *drying* plat-forms can be removed from the cabinet for cleaning.

Make the polythene cover:

Cut the polythene so that it is long enough to cover the dryer and there is enough to hang over the front and sides of the dryer chamber. If there are gaps at the side, the efficiency of the dryer will be reduced.

Place one long side of the polythene between two of the wooden batons and nail them together – this will help to prevent the polythene from tearing away from the wood. Do the same along the other long edge of the polythene. Fix one edge of the polythene to the back of the dryer. The polythene lid can be rolled up and down to open and cover the food while in the dryer.

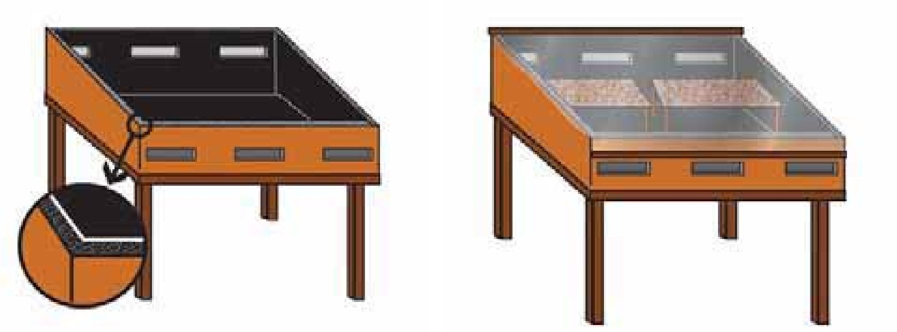


Figure 30: Brace Cabinet Dryer

Construction of a low cost mud solar dryer

This low cost mud *solar dryer*, illustrated in Figure 31 below, has been successfully used by families in rural Nepal. It can easily be built from materials that are locally available.

Figure 31: Mud dryer from Nepal
© Practical Action.

Materials required

- Mixture of clay and cow dung or finely chopped hay and dust of wood or rice husks
- Bricks or stones
- Small wooden sticks to make ventilation holes
- Wood for making trays
- Wire mesh (non-corrosive) or woven stems or thin sticks of wood
- Black paint (non-toxic)
- Polypropylene plastic (100 or 200 gauge)

Description of the dryer

The dryer should be slanted about 20 degrees from ground level and should be placed facing southwards.

1. Build the body and base of the dryer from brick or stones (whichever is locally available)
2. Cover the bricks or stones with a mixture of clay and cow dung mixed with finely chopped hay or rice husk or dust of wood. The mixture is used to avoid cracks.
3. Insert small wooden sticks into the mud of the front wall of the dryer while you are building it. Remove the sticks when the mud hardens to leave behind a small ventilation hole. Make sure you remove the sticks before they get set into the wall. The ventilation holes are for cool air to enter the dryer.
4. Make small windows or gaps in the higher side of the dryer (see figure 32) to release hot air.
5. Paint the inside walls with non-toxic black paint so that they absorb more heat from the sun (if you do not have paint you can cover them in soot)
6. Make food trays from wood and wire mesh, that can fit inside the base of the dryer.

4 Make a wooden frame that will be placed on the top of the dryer. Cover the frame with a sheet of polythene. The cover should be tight enough to prevent the entrance of flies and other insects and excessive air from the top.

Note on size: the size and capacity of the dryer depend on the quality of the products to be dried but it is recommended that the trays are no more than 10-12cm deep. Normally a 1.2m x 1.5m dryer is sufficient for one household of 4-6 family members.

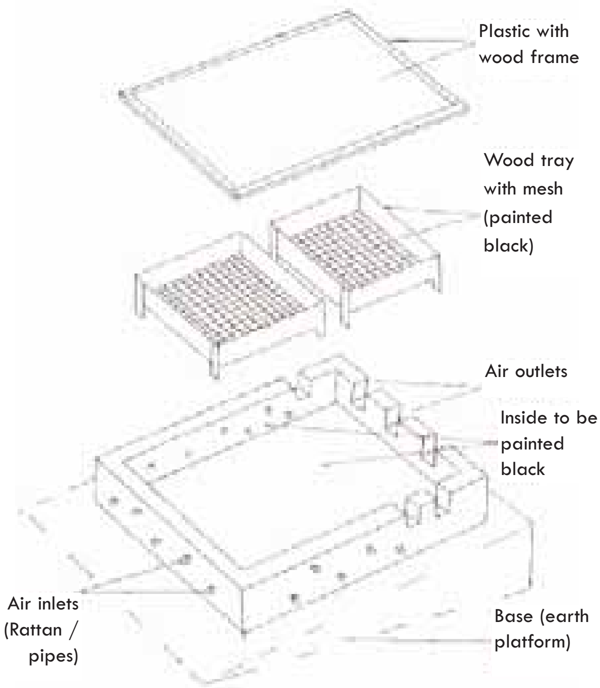


Figure 32: Components of the mud solar dryer

[See ITDG Food Chain 27 for further information https://practicalaction.org/docs/agroprocessing/food_chain_27.pdf]

Precautions

Care should be taken while handling the plastic cover of the dryer as it can be easily damaged.

The plastic cover should be replaced every two months or when it is no longer transparent

Cost

Between US$5 and US$8 depending on the size of the dryer and the availability of local skills and materials.

Annex 3

Sulphur cabinets

Sulphur cabinets are used for pre-treating fruit with *sulphur dioxide* prior to *drying*. A piece of sulphur is burned and gives off the *sulphur dioxide* gas. The gas is unpleasant and toxic, therefore the process has to be carried out in a closed, sealed place.

There are different types of sulphur cabinet available, or you can make your own from locally available material. Make sure that the gas cannot escape from the cabinet you use. If it does the fruit you are treating will not receive enough sulphur and you could breathe in the fumes which are unpleasant.

The sulphur tent

The sulphur tent shown in figure 33 consists of a wooden framework that holds up to 12 trays of fruit. The frame and trays should not be made of metal as this can be corroded by the gas. Use wooden or plastic trays.

Material needed

4 long wooden poles (to make the sides of the tent)
4 small lengths of wood (to place on top of the tent and hold the 4 poles together)
Planks of wood to make the sides of the trays (number to be determined by number of trays)
Wood or plastic mesh for the trays
Polythene cover

Construction details

1 Build a wooden framework, like a type of shelf, which is made to carry up to 12 trays.
2 Assemble the frames for the trays with lengths of wood. Ensure that the tray size is adequate to slide them into the tent. The trays should have a mesh bottom to allow the gas to permeate through to the top level.
3 Cover the entire structure with a tube of polythene (plastic sheeting), like a kind of sock. Seal the polythene at the base of the tent by piling earth onto the polythene. Make sure that the size of polythene you use is large enough to cover the whole framework and has at least 20cm extra at the base so a good seal can be made around the base.
4 Burn the sulphur in a small shallow container at the base of the shelves.

Figure 33: Sulphur tent.

The sulphur box

A structure similar to the sulphur tent can be made on a much smaller scale by using a heavy wooden box as the cover (see figure 34).

Materials needed

A heavy wooden box
Wood blocks to space out the shelves
Wooden frames for the shelves that fit comfortably underneath the box
Non-corrosive mesh for centre of shelves

Construction details

Select a heavy wooden box or crate. Make sure that it sits firmly on the ground with no gaps, so that gas cannot leak out.
Construct shelves to fit inside the wooden box (wooden frame filled with mesh).
Use blocks of wood (at least 35mm deep) to separate the shelves so that the gas can circulate at all levels.
Burn the sulphur in a small container at the base of the shelves.

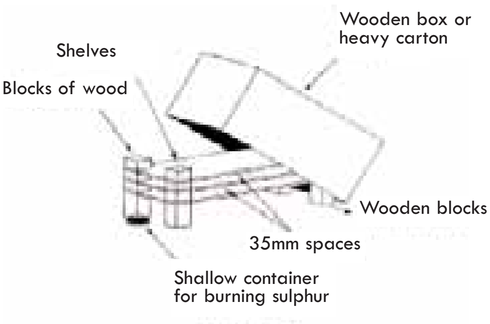


Figure 34: Sulphur box

Glossary

Acetic acid	Also known as vinegar. Acetic *acid* is a preservative that is used widely in the manufacture of *pickles*, chutneys and sauces. The *acid*ity helps to prevent the growth of *micro-organisms*. Acetic *acid* can be made by fermenting fruit or fruit waste.
Acid	A liquid with a *pH* lower than 7. *Acid* is added to manufactured food to improve the flavour and to balance excessive sweetness. *Acid*ic conditions (pH below 4.2) inhibit the growth of many food processing bacteria.
Acid food	A food with a *pH* lower than 4.6.
Alkali	The opposite of *acid* – a liquid having a *pH* higher than 7 (up to 14).
Bacteria	A microscopic living organism that is found in soil, water, air and on the surface of animals and plants. There are a range of bacteria that can survive in a range of conditions. Some bacteria produce toxins that are dangerous. Others can be beneficial (e.g. the *lactic acid* bacteria). Bacteria multiply very rapidly when the environmental conditions are favourable.
Benzoic acid	A permitted preservative in a number of products. It is widely used in soft drinks and similar products but its use is declining because some people are allergic to it.
Blanching	A short heat treatment that is carried out on vegetables prior to processing. Two main types of blanching – steam or water blanching. It is done to preserve the colour and to inactivate *enzymes*.
Boiling	Heating a liquid until it turns into vapour. At normal pressure, water boils when it reaches 100°C. When substances are dissolved in water, the boiling point is raised. At higher pressures, the boiling point increases and at lower pressures it decreases.
Brine (salt solution)	Brine is the name given to a solution of salt dissolved in water. Brine is used in the preparation of fermented *pickles*.
Brix	A measurement of the amount of total solids present in a product. It is measured in degrees (indicated by °) and commonly used for sauces and juices. A 30° Brix sauce has 30% *total soluble solids*. You measure the °Brix with a *refractometer*.
Case hardening	A problem that happens during *drying* of some fruit and vegetables. A hard skin forms on the outside of the partly dried product and prevents moisture escaping from the inside. It is caused by the temperature being too high at the start of *drying*.

Chlorine	The chemical present in bleach or hypocholorite that is used to sterilise water or equipment.
Chlorination	The process of adding *chlorine* to water to make it safe to use for drinking and for cleaning equipment. A 0.5ppm *chlorine* solution is used for drinking water and for water that is added to recipes. A 100ppm *chlorine* solution is used to clean/sterilise equipment.
Chlorophyll	A natural chemical that gives plants their green colour.
Concentration	The removal of water from a substance so that the remaining nutrients become concentrated. It is usually done by heating to drive off the water as steam, or by draining in a sieve or filter bag to squeeze out water.
Conditioning	A process that is carried out at the end of *drying*, especially for dried fruits that retain more moisture than dried vegetables. During conditioning, the dried fruit pieces are packed in a large container to allow the moisture that remains in the fruit pieces to distribute evenly throughout the fruit pieces. If the fruit pieces look wet or have beads of moisture on them when you re-check them, they must be returned to the dryer for further *drying*.
Drying (dehydration)	The removal of water from a food to preserve it.
Drop test	A simple test that can be used to determine when a *jam* or *jelly* reaches its end point (when it has the right *concentration* of sugar).
End-point	This term is used to describe the end of processing, specifically with relation to *jam* and *jelly* making. It is the point at which the *jam* has reached the correct amount of *soluble solids* and will form a gel when it cools down. The end point can be assessed by measuring the temperature or by doing a *drop test*, the wrinkle test or by measuring the sugar *concentration* with a *refractometer*.
Enzymes	Naturally occurring chemicals (proteins) that are found in the cells of plants and animals. They are responsible for ripening and development of taste and colour in plants. If they are not deactivated by processing they cause undesirable changes in the processed foods.
Ethylene	Ethylene is a gas that is produced by some fruit and vegetables as they ripen. It is not produced by all fruit and vegetables. Not all fruit and vegetables are sensitive to it. However, those that are sensitive to the gas can be induced to ripen by exposing them to the gas. Likewise, fruit or vegetables that are sensitive to the gas will spoil if they are kept with fruit or vegetables that produce the gas.
Fermentation	The metabolism of organic compounds in the absence of oxygen. Yeast ferments sugar to produce ethanol. *Lactic acid* bacteria ferment sugar to produce *lactic acid*. It is a process that is commonly used to make *pickles*.

Field heat	This is the temperature of a fruit or vegetables when it is harvested. In order to keep fruit and vegetables fresh for as long as possible, it is important to reduce the field heat as quickly as possible.
Food additives	A range of chemical and natural products that are added to foods for a number of reasons: • to prevent the growth of microbes and so help to preserve foods: *sodium benzoate*, sodium/potassium metabisulphite, *sulphur dioxide*. • to increase the *acidity*: citric *acid* (lemon juice), acetic *acid* (vinegar), which prevents the growth of bacteria. • for taste: salt, sugar and mono-sodium glutamate (MSG). • to give foods colour or to enhance the natural colour; food colourings. Some additives are permitted and others are not permitted for use in food and can be toxic.
Fungi/fungus	Fungi are a group of organisms that include *yeasts*, moulds and mushrooms. They grow on plant and other material. Some fungi are edible (mushrooms) and useful (*yeasts* for bread-making) but some are dangerous and should not be consumed.
Humidity	The quantity of water vapour in a given volume of air.
Jam	A fruit preserve that is made from fruit and sugar, boiled until it has a final sugar *concentration* of 68%.
Jelly	A fruit preserve that is made from extracted fruit juice and sugar, boiled until it has a final *concentration* of 68%. A jelly will not contain any fruit pieces.
Lactic *acid*	A product of lactic *acid* bacteria during *fermentation*. It reduces the *pH* of products, for example of *pickles*.
Low *acid* food	A food with a *pH* greater than 4.6.
Micro-organisms/Microbes	Microbe and micro-organism are general terms for the group of living organisms that are microscopic in size. The terms include bacteria, viruses, moulds, yeast and *fungi*.
Moisture content	The amount of water in a food or in the atmosphere.
Moulds	A mould is a fur-like growth caused by *fungi* that live on foods and other hosts. Some moulds are useful and harmless (eg penicillin). Others can be dangerous and should not be consumed.
Pasteurisation	Heating food to below 100°C to preserve it without causing major changes to the quality (taste and colour).
Pearson square	A method that can be used to calculate the proportions of two ingredients to mix together to reach a desired *concentration* in the final product.

Pectin	A natural chemical found in most fruits that can be used to form a gel (e.g. in *jam* making). Dried pectin powder is added to fruit that is low in pectin to make *jam* set.
pH	A scale from 1 to 14 that is used to measure the *acidity* (1-6), neutrality (7) or alkalinity (8-14) of foods.
pH meter	An instrument that is used to measure the *acidity* of foods or liquids.
Pickles	Preserves that are made from a mixture of fruit and/or vegetables with added spices. Some pickles are made by *fermentation* while others are made by adding vinegar. Pickles are generally acidic products that are eaten as a savoury accompaniment to a meal. They have a long *shelf life*.
Post-harvest treatment	Any of a number of processes that happen to a fruit or vegetable after is has been harvested.
Preservatives	Any chemical or natural compound that is added to a food to reduce the number and activity of bacteria, slow down spoilage of the food and extend the *shelf life* of the product. Sugar, salt, *lactic acid* and acetic *acid* are natural preservatives. Chemical preservatives include benzoic *acid*, sodium/potassium metabisulphite, *sulphur dioxide*.
Pre-treatment	A number of processes that are applied to fruit and vegetables ahead of the main process. Pre-process treatments for fruit and vegetables include washing, *blanching*, *sulphuring* and *sulphiting*.
Pulp	The fleshy edible part of fruit. It is usually a semi-solid mass made by extracting the edible part and mashing or mixing into a thick paste. Depending on how it is made, the pulp may be a smooth liquid with no lumps or it may contain pieces of fruit material.
Quality assurance (QA)	Management procedures that predict and prevent unwanted changes to the eating quality of foods, or prevent foods becoming unsafe
Quality control (QC)	Testing procedures that measure whether a food has the expected quality.
Refractometer	An instrument that is used to measure the amount (%) of soluble material (the *total soluble solids*: TSS) present in a solution. It is used to measure the amount of solids in *jam*, sauces and in fruit purees. From this, you can calculate the amount (%) of water present.
Relative humidity (RH)	The ratio of water vapour in the air compared to its saturation value at the same temperature.
Shelf life	The length of time that a product remains edible and fit for consumption.
Skin wrinkle test	A simple test that is used to determine the *end-point* of a *jam* or *jelly*.
Sodium benzoate	A chemical preservative that is often added to fruit products to preserve them after opening. Sodium benzoate releases benzoic *acid* which acts as the preservative. It can control the growth of mould and *fungi* in products such as *jams* and *pickles* that are opened and then re-sealed. Sodium benzoate works best in *acidic* conditions (*pH*<3.6).

Sodium hypochlorite	A chemical that is used to clean and sterilize water and equipment for food processing.
Solanine	A chemical that is produced by potatoes when they are exposed to light. It is produced when potato tubers turn green. Solanine is poisonous and should not be consumed.
Solar dryer	A piece of equipment – a box or tent - that collects and uses the natural heat of the sun to remove moisture from foods and dry them.
Soluble solids(SS)	Foods are made up of a mixture of solid compounds that are dissolved in water. In fruit and vegetables, the solid compounds are mainly sugars and starches.
Starter culture	This term is used in *fermentation*. A starter culture is something (e.g. a liquid or a dried powder) that contains the bacteria that are used in the *fermentation*. It is added to a *fermentation* to speed up the process and to prevent the growth of non-desirable bacteria.
Sterilisation	The killing or removal of all *micro-organisms* including bacteria and *fungi*. It is usually done by heating and holding at a high temperature for long enough to ensure all microbes are dead. It can also be done using chemicals.
Sugar thermometer	A thermometer that is specifically used for making sugar-based products such as *jam*, *jelly*, sweets and caramels. It has a temperature scale from 60°C to 220°C and the *end-point* temperatures for various sugar-based products are marked on it. The end point for *jam* and *jelly* is 105°C.
Sulphiting	A method of applying *sulphur dioxide* to fruit and vegetables. A solution of sodium or potassium sulphite or metabisulphite is made. This solution gives off *sulphur dioxide* gas. The vegetables are soaked in the sulphite solution so that sulphur soaks into the flesh.
Sulphuring	The exposure of fruits to *sulphur dioxide* gas. This is achieved by burning a piece of elemental sulphur in an enclosed place, such as a sulphur cabinet or tent. The *sulphur dioxide* gas is given off and soaks into the fruit (usually apricots).
Sulphur dioxide	A permitted preservative in many products. It is usually added as sulphite or metabisulphite through *sulphuring* or *sulphiting*. It is used to preserve the colour of dried fruits.
Sun drying	Using the natural heat from the sun to dry products. The products to be dried are spread onto a suitable surface (a metal sheet, or an open concrete floor) and left in the sun to dry.
Titration	A chemical method to calculate how much of one compound is dissolved in a solution. It can be used to determine the amount of *acetic acid* in vinegar.
Total soluble solids (TSS)	A measurement of the amount of dissolved material (generally sugars) in a product. Commonly used when making *jams*, sauces and purees.
Yeasts	*Fungi* that are involved in the *fermentation* and spoilage of sweetened or salted products.

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Fruit and vegetable storage and processing are very important for the livelihoods and health of Afghan households. Improved storage and processing can help families improve their diet throughout the year, by increasing the availability of diverse foods in the winter. Fruit and vegetable processing can also increase the income of families by reducing post-harvest losses, adding value to food products, enabling households to sell produce when prices are higher and by making produce easier to transport to the markets.

This Book is the first part of the manual "Home-based Fruit and Vegetable Processing in Afghanistan: A Manual for Field Workers and Trainers". This manual focuses on small-scale fruit and vegetable processing and preservation, for home consumption and small enterprises. It is designed to help anyone wishing to promote and disseminate fruit and vegetable processing techniques at community level.

Book One describes the basic principles of food storage and processing. It describes optimal practices for each stage of fruit and vegetable handling, from harvesting, post harvest handling and storage, to processing and packaging. Book One also includes information on hygiene and quality control.

You can also refer to Book Two, which provides a range of detailed recipes for each food processing technique described in Book One, using fruits and vegetables available in Afghanistan.

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