

# DRIED FRUIT





## Fruit processing toolkit



### DRIED FRUIT

#### 1.- General information

##### Dried Fruit - general information

Drying is one of the oldest methods of food preservation. It is still used widely to preserve foods for home consumption and for sale. Dried fruits are one of the most popular products made by small-scale processors.

Drying removes the water from foods so that the growth of micro-organisms is inhibited. It also reduces the weight and bulk of foods which cuts down on transport and storage costs.

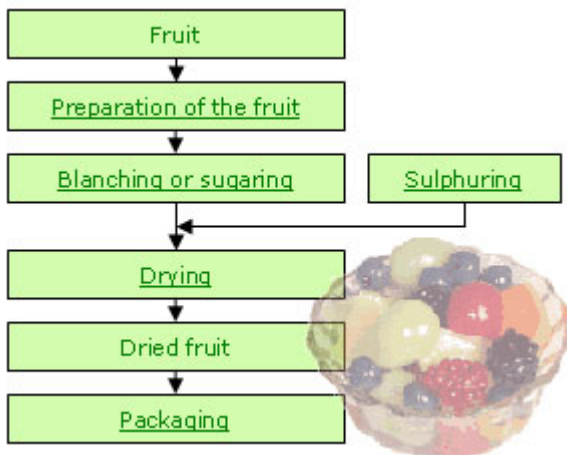
Sun drying is the simplest and cheapest method of drying. It is used for high volume foods such as grain, rice, sultanas and raisins. The disadvantage of sun drying is that the processor has very little control over the drying conditions and the quality of the dried fruit.

There are two main forms of dried fruit- semi-moist and dried fruits. Semi-moist fruits, such as grapes contain naturally high levels of sugar which means they can be preserved with a higher moisture content than most other dried fruits. Semi-moist fruits can have a moisture content as high as 25% and are consumed as they are without rehydration. The sugar content of other fruits can be increased by soaking the fruits in sugar solution prior to drying. These fruits are known as osmotically dried fruits.

To make higher quality products, processors use an artificial dryer. There are several types of dryer available (solar, diesel, electric, biomass powered) according to the different needs of the user.



## 2.- Processing details for dried fruit production



### A.-Preparation of the fruit

All fruit to be dried should be hand picked and not shaken from the tree.

To obtain maximum yields of top quality dried product, all fruit should be ripe and free from bruising. Any rotten or bruised fruit should be thrown away.

For maximum profitability, the dryer should be loaded to maximum capacity as often as possible, therefore it is advisable to buy more fruit than is required.

Bananas have a low level of acidity and turn brown very rapidly after peeling and cutting. To prevent this, they should be immersed in water containing sodium metabisulphite (400 parts per million of sulphur dioxide) immediately after peeling.

Unpeeled fruits should be washed in a mild disinfectant solution made from one part of bleach to 50 parts of water. Care must be taken not to break the skin of the fruits as this will contaminate the flesh.

Gloves and aprons must be worn to protect the workers hands and clothes. Ten litres of treated water will be sufficient for about 20kg fruit.

The wash water should be changed after this amount has been washed as it becomes contaminated by the fruit.

Soft fruit, such as berries and apricots, are delicate and should be handled carefully to avoid bruising. Washed fruits are carefully peeled to remove all the peel and any damaged parts of the flesh. Fruits are cut into slices of varying thickness depending on the type of fruit and the dryer. The following points are useful to consider: thick pieces dry at a slower rate than thinner ones; very thin pieces tend to stick to the drying trays and may be difficult to remove; thicker pieces may not dry fully in the centre and will not store well; packets of mixed thick and thin pieces do not look attractive.

Recommended slice thickness for various fruits:

### Food Chain 31 (Ref 36)

Pineapple: 2-3mm

Mango: 6-8mm

Banana: 5mm

Tomato: 3-5mm

Only stainless steel knives should be used to peel and chop the fruit.

Other metals will discolour the fruit flesh.

## B.-Blanching or sugaring

This stage is optional, but some processors choose to soak fruits in a sugar syrup prior to drying. There are several benefits of including this process. There are also constraints to sugaring.



Fruit pieces are immersed in a concentrated sugar solution for up to 18 hours. They are rinsed in clean water to remove any excess syrup before drying.



Most vegetables and some fruits are blanched before drying to inhibit enzyme activity and to help preserve the colour.

The material is cut into appropriate sized pieces and plunged into boiling water for up to 5 minutes. They should be blanched in small batches to ensure that each piece is properly heated through.

If too many pieces are put into the water at one time, the water temperature will drop and prolong the blanching time. After blanching for the required time, vegetables are rapidly cooled by plunging into cold (or iced) water.

## C.-Sulphuring

Sulphuring or sulphiting is an optional stage of processing. The main benefit of sulphuring is to preserve the fruit colour. Some consumers object to chemical preservatives and prefer naturally dried fruits.



Sulphur dioxide gas (SO<sub>2</sub>) is applied to the fruit pieces by placing them in a cabinet or tent in which sulphur is burned. The gas is absorbed by the fruit. For most fruits, 5-6g sulphur per kg food is adequate. The gas given off is toxic and corrosive. Therefore, sulphuring should be carried out in a well ventilated place, using appropriate equipment. See the information on sulphuring for more details. Sulphite can be included in the sugar syrup (as sodium or potassium metabisulphite).

## **D.-Drying**

Fruit pieces are arranged on mesh-bottom trays so that they are not touching or overlapping. The fruit should be loaded into the trays as soon as it is cut. This prevents the pieces from sticking together and allows the drying process to start as soon as possible.

The trays should be brushed clean to remove any old fruit pieces.

The trays should be loaded into the dryer as soon as they are ready. The dryer doors should be closed after each tray is loaded.

Direct sunlight should be avoided as this bleaches the colour and reduces the level of vitamins A and C. The drying temperature should be controlled to avoid over-heating and spoilage of the fruit. Most fruits are dried at about 60-70 deg C.

Fruits are dried until they have the desired final moisture content (15% for conventionally dried fruits; 20-25% for osmotically dried (sugar-treated fruits)).

## **E.-Packaging**

Dried fruits should be packaged immediately after drying to prevent them absorbing moisture from the surrounding air. After drying, fruits can be packed in bulk in sealed moisture-proof polyethylene bags then packed into smaller packets at a later date.

## **General**

All equipment must be thoroughly cleaned each day to prevent contamination by insects and micro-organisms.

## **3.- Information on drying**

### **A.-Principles of drying**

The following gives basic information about drying. Although it seems a simple technique, drying is quite technical and requires a certain amount of knowledge to ensure it is carried out efficiently and safely. More detailed information about the principles of drying can be found in the references.

#### **Axtell (2002)**

Foods are dried when the water contained within them is removed into the surrounding air. It first moves to the surface of the food and then evaporates as water vapour.

#### **Fellows (2000)**

For effective drying, the air should be hot, dry and moving. The three factors are all inter-related and for optimum drying, each one has to be correct. The dryness of air is known as relative humidity (RH) (0-100%). Air with 0% RH is completely dry. Air with 100% RH is completely saturated with water vapour. Air can only remove water from foods if it is not fully saturated with water vapour.

Humidity is affected by the air temperature. At higher temperatures the humidity is reduced and air can carry more water vapour.

In solar dryers the air should be 10-15°C above room temperature. In artificial dryers it should be 60-70°C. The RH of air entering a dryer should be below 60%. Dryers are fitted with a fan or exhaust to circulate air and remove the damp air.

### Axtell (2002)

When a new food is to be dried, processors must carry out a series of tests to find out the rate of drying. This information is used to find the optimum drying conditions for the particular food.

### Fellows (2000)

The rate of drying affects the quality of the dried food and the amount of fuel used for drying, and hence the cost.

To find the drying rate, the food is weighed, placed in the dryer and left for 5-10 minutes. It is removed and re-weighed then put back in the dryer. This is continued until the weight does not change. The rate of drying can then be calculated.

Typical drying rates are 0.25kg per hour for solar dryers and 10-15kg per hour for artificial dryers. If the rate is lower than this either the temperature or air speed are too low or the relative humidity is too high. The test sample is left in an airtight container for one day, then re-weighed to check if any more moisture has been lost. If it has, the fruit is likely to feel soft or be mouldy.

Case hardening is a condition that sometimes occurs during drying. The outside layer of the fruit dries too quickly and becomes quite hard. This hard dry layer prevents any more moisture from being lost from the fruit. The centre of the fruit remains moist and is then prone to spoilage during storage.

The most common cause of case hardening is the use of drying temperatures that are too high. It can be prevented by using lower temperatures and controlling the rate of drying, especially during the early stages.

The moisture content of the food can be measured with a moisture metre. Alternatively a small sample of the dried food is ground into small pieces, weighed and placed in an oven at 100°C for 4 hours. It is reweighed and the moisture content calculated.



$$\text{Moisture content (\%)} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} * 100$$

The final moisture content of the dried food shows whether it will be stable during storage. Once a satisfactory product has been made, the same drying routine should be used for all batches of that particular fruit. To ensure safe storage of dried foods, they should have the following final moisture contents:

- Fruit and meat
- Vegetables
- Grains 10-15%

The stability of a dried food during storage depends on its ability to pick up moisture from the air. Different foods have different susceptibilities, but the risk is higher when the humidity is high. Dried foods should be packaged in moisture proof material to prevent spoilage. Back to dried fruit flow chart.

## **B.-Practical aspects of food drying**

### **B.1.-Selection and preparation of fruit**

To produce good quality dried fruit and vegetables that are acceptable for both export and local consumption, there are several factors to consider. These include the following:

#### **NRI (1996) (Ref 35)**

Purchase of good quality fresh produce

Careful transport and storage

Proficient preparation of produce

Correct loading and operation of the dryer

Drying to the correct final moisture content

Proper packaging and storage of the dried product

Achieving good product quality

Efficient management of all operations to assure quality, minimise losses and maximise business profitability.

All activities must be carried out with due diligence at all times with regard to cleanliness, hygiene and food safety aspects.

#### **B.1.1.-Location of dryer**

The solar dryer should be positioned in a flat area, out of the shade of buildings or trees, so that it is fully exposed to the sun throughout the day. If the wind blows predominantly in one direction for long periods, the dryer should be placed end on to the wind. This will reduce the cooling effect of the wind blowing directly into the drying cabinet and lengthening the drying times. It will also reduce the chance of dust entering the cabinet.

#### **B.1.2.-Drying**

During the first few hours of drying, particularly during hot and sunny weather, the fruit may dry so quickly that moisture condenses on the inside of the plastic covers. This can be avoided by opening the door slightly (20mm) to increase air circulation. The gap should be covered with mosquito mesh.

This will only be necessary on the first day and during the sunniest part of the day. The doors should only be kept open for a minimum period of time and closed again as soon as the weather becomes cloudy.

The doors should never be left open overnight. In poor weather, drying will stop. If it rains, it will rapidly cool the dryer and condensation may form on the plastic cover. It will take some time for the dryer to start working again once the rain stops. Putting a portable thatched cover

over the dryer when it rains will help to reduce the impact. In fine and sunny conditions, the fruit slices should be dry after two full days in the dryer. It is essential to test the slices to check they are dry.

Judging dryness is an important skill. Experienced processors will know when the fruits have reached the desired level of dryness. To check dryness, several pieces of fruit should be removed from the dryer and allowed to cool for a few minutes.

A few simple tests can show if the fruit is dry: Squeeze the fruit pieces. If no moisture comes out, it is dry.

Tear a piece of fruit in half. There should be no moisture in the middle. The slices should be kneadable and pliable, but do not stick together.

If the slices are not fully dried, they should be allowed to continue for one to two hours, then checked again. The final moisture content should be around 10-15%.

### **B.1.3.-Unloading the dryer**

When the fruit is dry, it should be unloaded from the dryer as quickly as possible. This should not happen early in the morning since the overnight dew and high humidity may cause condensation of moisture onto the fruit. Take the trays out of the dryer and to a clean, dry area. Remove the fruit from the trays and sort it on the basis of size and colour. Discard any over-dried pieces. Return any under-dried pieces to the dryer. This should all be done as quickly as possible to prevent the absorption of moisture from the air and contamination from dust or insects.

### **B.1.4.-Packaging and storage**

Packaging should be carried out immediately after unloading the trays since the dried slices will re-absorb water. It should be packaged in clean plastic bags using clean hands and gloves. For extra protection, it is recommended to 'double-bag' the fruits. The moisture contents of different batches of dried fruits will vary slightly. To ensure that the packaged products have a uniform moisture content, dried fruits from different batches should be mixed together during packaging.

Each bag should be clearly labelled with the date it was packed and the name of the producer. The packed bags should be stored in a cool dry place that is secure and safe from rodents and pests. It should not be stored for more than one month before being sold.

### **C.-Quality changes during drying**

To help with selecting the correct dryer and drying conditions, it is useful to be aware of the factors that affect fruit and vegetables during drying.

The product may be adversely affected by light. For example, dark green colours can be bleached and pale colours may darken. The levels of vitamins A and C are reduced by sunlight, thus the nutritional value is reduced.

**It is advisable to dry fruits and vegetables in the shade when possible.**

Excessively high temperatures during drying can lead to high levels of shrinkage in the food. This may make them irregular in shape and unattractive to the consumer. High temperatures also increase the tendency to turn brown. Dried vegetables that are very shrunken are more difficult to rehydrate.



**The temperature and rate of drying should be strictly controlled.**

Rehydration of the product is an important quality aspect. Fruits and vegetables that are over-dried do not look attractive and are difficult to rehydrate. Over-drying is also wasteful in terms of lost manpower and energy.

**There is a fine balance between drying to a moisture content low enough to preserve the fruit and high enough to make an attractive product.**

## **D.-Selection of dryer**

**Sun drying** of fruit and vegetables on the ground should be avoided as it is very difficult to control the quality of the product. When sun drying is used, the fruit and vegetables should be dried on mesh trays on racks that are raised above the ground so that the air can circulate around them. This speeds up the drying process. The fruit or vegetables are loaded onto trays in a single layer. The maximum capacity should be 6kg vegetables per square metre of tray. They should be turned or moved every hour during the first drying period to speed up drying and improve the quality. The trays of produce should be dried in the shade to prevent loss of colour and nutrients. Some fruits are dried directly in the sun.

**Shade drying** is more dependent on air movement over or through the fruit or vegetables. The drying rack should be placed in a position that can take advantage of any wind. In dry air conditions with ample circulation, shade drying can be accomplished almost as quickly as sun drying. In conditions of high sunshine and low humidity, sun drying can be finished in one day. If the produce has to be dried overnight, it has to be protected from evening rains and early morning dew.

Solar drying in a cabinet dryer can be used for most vegetables and fruits. During the initial stages of drying it is essential to ensure that there is no condensation of water inside the dryer. Condensation is caused by insufficient air flow. The operator should ensure that the air intake and outlet vents are wide open to prevent this happening.

**Solar drying** is dependent on the sun shining. There is no drying in cloudy or rainy conditions or overnight. This prolongs the drying period and can reduce the quality of the products. For a small business, solar drying is really only a viable option in dry sunny climates.

**Artificial drying** is the most controllable method of drying. It is also the most expensive as it requires a drying cabinet that is heated by electricity, gas or biomass. There are several types and sizes of dryer available to suit processors needs. The advantages are that the drying rate can be carefully controlled regardless of external climatic conditions to make a high quality dried product.

## **4.-Recipes/Methods**

### **Dried fruit recipes/methods**

The following methods have proved successful for the various fruits

**ILO 1986 (Ref 34)**

#### **Banana**

The fruit should be ripe and sweet, but not soft and brown. Cut into thin slices (5-7mm thick) and sulphur. Or, sulphite by dipping in a 2000ppm SO<sub>2</sub> solution for 1 minute. Dry the fruit in a

single layer at 60-75degC until hard and brittle (equal to a moisture content of 12%). Avoid overheating to prevent the banana from darkening.

**ILO 1986 (Ref 34)**

### **Breadfruit**

Peel, core and cut into ships or thin slices. Follow the same method as for bananas.

**ILO 1986 (Ref 34)**

### **Apple**

Peel, core and cut into slices or rings. Sulphur for 60 minutes and dry until the fruit is leathery and has no moist area in the centre.

**ILO 1986 (Ref 34)**

### **Pears**

Peel, cut in half lengthwise, core and make slices about 3-5mm thick. Sulphur for 60 minutes and dry until the texture is springy.

**ILO 1986 (Ref 34)**

### **Peaches**

Peel carefully and avoid bruising. Dry as for pears until pliable but leathery.

**ILO 1986 (Ref 34)**

### **Apricots**

Cut the fruit in half and remove the stone. Apricots dry more quickly if they are sliced or quartered, but check that there is a market for these smaller pieces. Sulphur for 60 minutes. Dry until pliable but leathery.

**ILO 1986 (Ref 34)**

### **Plums**

Cut in half and remove the stone. Either check or blanch the fruits, then sulphur for 60 minutes. Dry the same as apricots.

**ILO 1986 (Ref 34)**

### **Berries**

Wash and check the berries. Sulphur for 60 minutes. Dry until the berries are hard and there is no visible moisture when crushed. Strawberries are not suitable for drying.

**ILO 1986 (Ref 34)**

### **Figs**

If the figs are small or have been partly dried on the tree, they can be dried whole without checking or blanching. If they are large, cut in half, check or blanch and dry until they are soft and leathery but still slightly sticky.

## Dates

Dates may be partially or wholly dried on the palm depending on the climate. Where they are partly dried they can then be sun or solar dried whole without any pre-processing. Direct sunlight is essential. Alternatively, the dates can be pitted, halved and sulphured before drying. The semi-moist date halves can be pressed together to form a paste.

ILO 1986 (Ref 34)

## Grapes

Grapes are washed, checked and sulphured for 60 minutes. They are dried until pliable and leathery. The seedless varieties of grape are preferable for drying.

ILO 1986 (Ref 34)

## Mango 1

Peel and cut off the two fleshy cheeks. Cut into thin slices. Treat with sugar (optional) and sulphur for 60 minutes. Dry in the shade. Well dried mango will be golden brown and pliable. Different varieties of mango have different drying requirements. If the fruit goes brown during drying, the temperature should be reduced.

Azam-Ali et al, 2003 (Ref 29)

## Mango 2

Peel the mangoes and cut into slices 6-8mm thick. Prepare a sugar solution from 1 litre of boiling water, 700-800g sugar, 3g potassium metabisulphite and 20ml lemon juice. Soak the slices in this syrup for 18 hours. Drain and place on aluminium trays coated in cooking oil or glycerine. Dry, either in the sun or a solar/artificial dryer until the final moisture content is 15%.

ILO 1986 (Ref 34)

## Papaya

Dry as for mango.

## 5.-Sugaring fruit for drying

There are various methods of applying sugar to fruits. The simplest is to dust with a fine layer just before drying. This gives the fruit a sweet coating and may help to slow down browning. Fruit pieces can be dipped in a concentrated sugar solution, made by dissolving sugar (sucrose) in water. While the fruit is immersed in the syrup, water is drawn out of the fruit by a process of osmosis (the principles of osmosis are that water diffuses through a semi-permeable membrane from a weak to a stronger solution until both solutions are the same strength. The sugar also diffuses through the membrane, but at a much slower rate than the water.)

When the fruit is immersed in a concentrated sugar solution, water equivalent to over 50% of the initial fruit weight can be removed, which reduces the amount of water that has to be

removed during the drying phase. The increased sugar concentration in the fruit acts as an extra preservative which means that the fruit can be dried to a higher moisture content (25%).

**Advantages of sugaring** During osmosis, the material is not subjected to a high temperature over an extended time which minimises heat damage to the colour and flavour.

A high concentration of sugar surrounding the material prevents discolouration by enzymic or oxidative browning. The fruits can have a good colour without the need for chemical treatment such as sulphuring.

As water is removed by osmosis, some of the fruit acid is removed along with it. Combined with the uptake of a small amount of sugar, this produces a blander and sweeter product.

**Disadvantages of sugaring** Sometimes a thin layer of sugar is left on the fruit after drying, which may be undesirable. It can be removed by rinsing the fruits after soaking and before drying. The process produces a dilute syrup as a by-product. The syrup can be brought back to full strength by concentrating or adding more sugar. However, there is a limit to the number of times it can be re-used. To be more cost effective, the syrup could be used to make fruit nectar.

Including this step adds unnecessary complications to the drying process. Sugar may be an expensive commodity which makes the option financially unattractive to small-scale processors.

## 6.-Preparation of sugar solution

A weighed amount of sucrose is dissolved in water to make a solution of a known strength. The water must be heated to dissolve all the sugar.

For example, to make a 67% sugar solution, 67g of sugar are dissolved in 100ml water. The strength of a sugar solution can be measured using a refractometer, which calculates the total soluble solids as degrees Brix.

After the syrup has been used to soak fruit, the strength becomes reduced. It can be made back to the desired concentration by dissolving more sugar. The Pearson Square calculation is useful to determine the amount of sugar to add.

The concentration of the sugar solution and the time of soaking are dependent on the material and the desired level of water removal.

The following technique has been used successfully with banana, mango and papaya: Fruit pieces are soaked for up to 18 hours in a 67% sucrose solution, which will remove about 40% of the water. The long soak is followed by a one hour soak in a 60% sugar solution that contains 1% SO<sub>2</sub> (as sodium metabisulphite). The fruit is finally rinsed in cold water to remove the stickiness. It is then ready for drying.

## 7.-Dried mango slices

Fruits should be half-ripe and without fibres.

Wash and peel the mangoes and cut into slices (6-8mm thick) with a stainless steel knife. Soak the slices for 18 hours in a sugar solution made from the following:

1 litre boiling water

7-800g sugar (to make a 40°Brix solution)

potassium metabisulphite (3g per litre of water)

lemon juice (2 teaspoons per litre of water)

After soaking, drain the fruit slices and place on glycerine coated aluminium trays. Dry in the sun or a solar dryer until the slices have a final moisture content of 15% Package in small bags (about 150g), label and store in a cool dry place. When stored properly, the dried slices have a storage life of about 9 months.



## 8.-Dried Tomatoes

**Reference. FAO (1997). Ref 26.**

Unblemished, firm, red, ripe tomatoes

1. Select unblemished ripe tomatoes of a uniform colour.
2. Wash in clean water and leave to drain.
3. Remove the stalk. Using a stainless steel knife, cut the tomatoes lengthwise into quarters or eighths. Remove the seeds and dry separately in the shade.
4. Blanch the tomato pieces in boiling water for 1-2 minutes. Cool in drinking water and drain.
5. Immerse in a solution of sodium metabisulphite (prepared with 1g metabisulphite per litre of water). Soak for 15-20 minutes. Drain and place on the dryer trays in a single layer. It is better to use trays with a plastic mesh rather than a metal mesh.
6. Dry until the pieces become brittle.
7. Cool and package in polyethylene or polypropylene/cellophane bags.
8. Label the bags, pack in cardboard boxes and store in a cool dry place out of direct sunlight.
9. Weigh the pectin so that it equals 0.5% of the total weight of the juice-sugar mixture. Blend with the 1% of sugar that was kept aside.
10. The dried product can be stored for up to 1 year.

