

Drying of Fruits & Vegetables



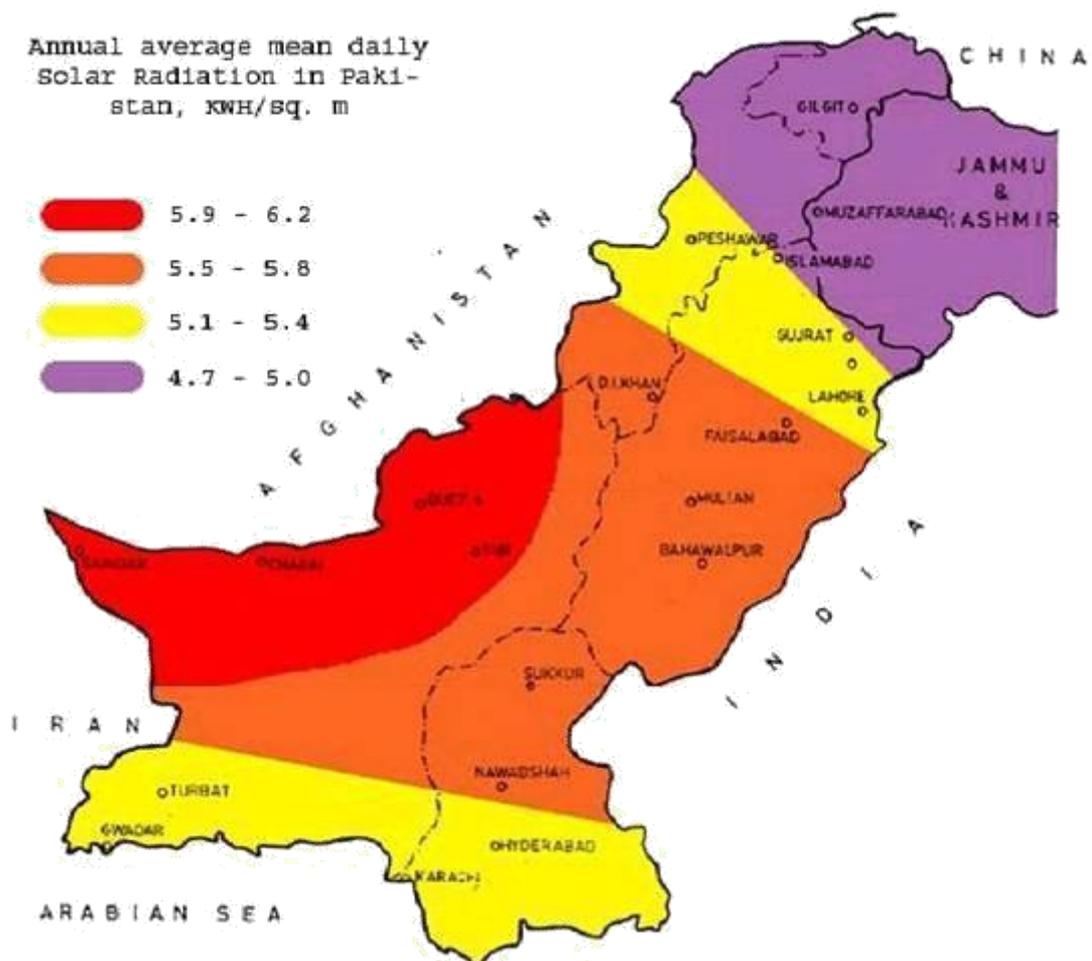
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Solar Energy

Among all renewable energy sources, solar radiation is in abundance, freely available, widely distributed and can easily be converted into other forms of energy. This makes solar energy the most promising future source of energy. On reaching the earth its peak value at the sea level is 900 to 1000 W / m² global irradiation falling on the horizontal surface is about 1.5 - 2.0 MWh / m² per year. This value is more than 10,000 times the current value of all type of energies that the world is using. The mean global irradiance falling on horizontal surface in Pakistan varies from 4.7 -- 6.2 kWh/m² the number of clear sunny days in the country varies from 250 in the Northern region to above 300 days in most part of the rest of the country.



SOLAR DRYER

Agriculture forms the base of the Pakistan economy, which produces large quantities of grains, fruits and vegetables. But due to the inadequate post harvest care, it is estimated that about 20-30 percent of the produce is wasted. If solar dryers are used to remove excess moisture from the product before storage, their quality will not deteriorate during storage and insect infestation will be reduced. Similarly, large quantities of excess vegetable and fruits, now being wasted, could be solar dried in a controlled manner for use during off-season.

Basic Principle

A solar food dryer consists of a flat box (frame) placed at an angle, with an open bottom and top, so that the air can circulate. Corrugated metal sheet, painted black, is placed on the bottom of the box. The black color absorbs the sunrays and heats the air above. The frame is covered with glass, transparent plastic foil or a plain garden plastic. The warm air reaches 40-50°C, rises and leaves the heating box through the top opening and flows through the drying chamber with the drying screens. Cool environment air is sucked off through the bottom opening.

The dryer's angle must be adapted to the respective geographical latitude: In Pakistan steeper (35-45°). With a flat angle, air circulation can be improved by adding a chimney. The solar dryer only works with direct solar radiation and works best during dry periods when there is little humidity in the air.

A.-Preparation of the fruit

All fruit to be dried should be handpicked 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

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 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 (SO₂) 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 interrelated 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.

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

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, meat vegetables and 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:

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 maximize 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 overdried 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

Apple:

Golden apples are cleaned, cored and sliced to 3-5 mm thick. To prevent browning, the apples can be immersed for 1s in 2% citric acid or 2% Na₂S₂O₅ solutions immediately after slicing. The apples dried under light conditions becomes a little brown but the ones that are dried without exposure to light are kept their natural, light colour. The choice of drying conditions depends on the consumer's demand. Dried apples have a water activity of 0.38 and a yield of 15%.

Apricots

Wash apricots. Cut in half and remove pits. Place apricots on drying trays, skin side on top. Dry for approximately 48 hours at 38°C or until pliable, note: dehydrated apricots will be darker in color than store bought, but have wonderful flavor. To rehydrate: soak in hot water for 15 minutes. Dried apricots make nutritious snack treats.

Dates

Wash dates, remove the pits, and cut in half lengthwise. Place cut-side down on dehydrator tray. Dehydrate dates at 38°C until leathery (+/- 20 hours). Dried dates are great for snacking by themselves, for bakery, for trail mixes, even cereal/oatmeal additions.

Figs

Wash figs, remove the pits, and cut in half lengthwise. Place cut-side down on dehydrator tray. Dehydrate figs at 38 Centigrade until leathery (+/- 20 hours). Dried figs are great for snacking by themselves, for bakery, for trail mixes, even cereal/oatmeal additions.

Grapes / Raisins

It's best to use seedless grapes. Remove the grapes from the stems and wash. Check the grapes by dropping them into boiling water until the skins crack (should take no longer than 2 minutes). Remove from water and drain. Dehydrate grapes at 100% for about 80 hours, until leathery and they look similar in consistency to store-bought raisins. (no moisture pockets).

Mangoes

Wash peel, remove seed. Cut into 1/4" slices, Dehydrate mangoes at 38 °C for approximately 20 hours. (Finished consistency should be pliable), Mangoes are good for fruit leather. Dried mangoes make a wonderful snack. Rehydrated mangos are best used in bakery, or try it with your favorite chutney.

Plums / Prunes

It is known that certain treatments used to modify the waxy cuticle of the surface of various fruits (prunes, grapes, cherries, etc.) accelerate the drying as a result of an increase in the skin permeability. Dipping in olive oil emulsions is a traditional practice in direct solar drying of pieces and it is recorded that this increases the drying rate of grapes approximately 30%. Different olive oil concentrations combined with sodium or potassium carbonate or ethyl esters of fatty acids are used for this purpose. Prunes can be dried at 55-60°C in solar tunnel driers. At this temperature, prunes pretreated with 2% ethyl oleate or 2% olive oil+4% potassium carbonate dried in 3-4 days. Dried plums make a tasty snack, but eat in moderation (for their laxative effect). Use in bakery, sweet and sour dishes, etc.

Peach

Peaches are washed, destoned and sliced 1-2 cm thick. The thickness of the slices is very important since very thin slices causes hardening and brownish colour in the final product. Different concentrations of Na₂S₂O₅ and citric acid can be used as pretreatment agent: 2% citric acid for 30s, 1 Na₂S₂O₅ for 1 s, and 1 % citric acid + 0.5% Na₂S₂O₅ for 1 s. Peaches which are consumed directly or used in recipes can be dried at 45-50°C in 2 days. The yield of the final product is 11 % and final moisture content is about 8.5%.

Strawberries

Wash strawberries and remove caps. Cut into 1/4" slices. Dehydrate strawberries at 38 °C for about 30 hours. Finished consistency should be leathery. Strawberries make nice fruit leather.

Cabbage (Red or Green)

Wash, trim outer leaves. Remove core and shred. Steam blanches for 2 minutes. Dry at 38 °C for 18 hours or until crisp. To rehydrate, soak in cold water with a little lemon juice for 30 minutes and drain. You can add dried cabbage directly to soups or stews without rehydrating. Note: Red cabbage loses some of its color when rehydrated.

Carrots

Before loading into the dryer, carrots are peeled, washed, cut into small cubes and treated with 2% sodium metabisulfite solution for 1s and 10s or dried as natural. Carrots can be dried at 50-55°C for 1-1.5 days to a final moisture content of 7.5 %. Naturally dried carrots loss their bright orange colour. The sodium metabisulfite treated ones preserve their colour to the largest extent.

Eggplant

Wash and cut into 1/2" slices, dry at 38 °C for about 20 hours or until leathery, to rehydrate, soak in hot water for about 30 minutes and drain. Dried eggplant works well in casseroles.

Garlic Cloves

Use firm cloves without bruises. Peel cloves and cut in half. Remove the sprout in the middle. Dry at 38 °C for about 6 hours or until crisp. To rehydrate, soak in cold water for about 3 hours in the fridge and drain. To make garlic powder, grind the dried garlic in a blender or seed grinder. For garlic salt, mix ground-dried garlic with 4 parts salt.

Mushrooms

Rinse quickly, firm and cut into 1/4" slices. Dry at 38 Centigrade for 18 hours or until crisp. To rehydrate, soak in cold water for 30 minutes and drain. No need to rehydrate if using in soups or stews.

Okra or lady finger

Okra is one of the most popular vegetables consumed in tropical and subtropical countries, because of its adaptability and resistance to hot and humid weather. Before loading into solar dryer, okra is washed and its head is removed. One of the following treatments can be applied to okra prior to solar drying: dipping in 0.2% Na₂S₂O₅ for 20 min; 0.1% Na₂SO₃ for 30min;

0.3% Na₂S₂O₅ 10 min; 2% Na₂S₂O₅ for 1s, and 3 minutes of blanching followed by dipping in 0.2% Na₂SO₃ for 15 min, and finally blanching and dipping in 0.2% Na₂SO₃ for 15 min. On the basis of colour, flavour and microbiology of the final product, it was observed that high quality dried okra was obtained using 2% Na₂S₂O₅ dipping as a pretreatment and drying of okra at 50-55°C in the solar dryer under dark conditions. Drying time was about 1day. Blanching of okra before drying needs ice-bath dipping. Therefore it is not considered as a practical method.

Dry Onions

A large part of the dehydrated onion production is used as seasoning in production of catsup, chilli sauce and meat casseroles, as well as cold cuts, sausages, potato chips, crackers and other snack items. Food service outlets also use dehydrated onions because of its convenience in storage, preparation and use. Before drying, onions are peeled and sliced into desired shapes. Onions can be dried at 45-50°C for 2-3 days to a final moisture content of 15 % in tunnel solar dryers. Sodium metabisulfite dipping can be used to preserve colour. Drying temperatures of onions should not exceed 50°C in order to prevent browning of the product. The yield in onion drying is 8%.

To rehydrate, soak in hot water for 15 minutes and drain. No need to rehydrate if using in soups or stews. Make onion flakes and onion powder by grinding in a food mill or blender. For onion salt, mix onion powder equally with salt.

Dry Peas

Remove peas from the pods. Steams blanch for 3 minutes and drain. Dry at 38 °C for 12 hours or until brittle. To rehydrate dried peas, soak in hot water for 30 minutes and drain. No need to rehydrate if using in soups.

Bell Peppers

Wash and core pepper. Dice or cut into 1/4" slices. Dry at 38 °C for 24 hours or until brittle. To rehydrate dried peppers, soak in hot water for 20 minutes and drain. No need to rehydrate if using in soups.

Potatoes

Drying potatoes is a smart way to store this vegetable for later use. There are a few different methods of doing this, including a dehydrator, solar oven or conventional oven. Follow the listed steps to figure out how to dry your potatoes. Wash the potatoes you wish to dry and remove any areas that have spoiled. Skins can either be peeled, or left on if you wish for vitamins. Bring a large kettle of water to a boil and add salt to your taste. Slice the potatoes into rounds that are 1/8-inch thick and place these slices in a vegetable basket and dip that into the boiling salt water. Wait for the water to return to a boil, and continue boiling them

for about seven minutes. Take the potatoes out of the kettle and place the basket in ice water for approximately 15 minutes. Spread the potatoes in a single layer between paper towels and blot them to dry, put the potato slices on racks that are coated lightly with vegetable-oil spray. Put the slices in a single layer, and make sure they are not touching one another.

Spinach

Wash well and remove stems. Dry at 38 °C for 10 hours or until brittle. To rehydrate, soak in hot water with a little lemon juice for 15 minutes, drain well.

Tomatoes

Due to the increasing demand to dried tomatoes from the industry, especially from the soup manufacturers, interest in producing high quality dried tomatoes has been increasing. Therefore, it is important to establish a drying method, which yields products with higher sensory and sanitary quality in a shorter drying time compared to the conventional sun-drying method. Both 2% Na₂S₂O₅ and 2% citric acid pretreatments can be used to protect the bright, red colour of tomatoes. However, citric acid did not prevent the growth of moulds and yeasts effectively. Therefore, dipping into sodium metabisulfite solution for 3 minute is the best type of pretreatment. Tomatoes can be dried at 55°C in solar tunnel dryer without a darkening in color. At this temperature the drying takes 4-5 days to final moisture content of 11 %. To rehydrate, soak for 15 to 30 minutes in cold water.

Red Pepper

Red peppers are deseeded, cut into small pieces, and washed before loading into the tunnel solar dryer. Pretreatment with 2% Na₂S₂O₅ for 1 second gives the best colour. Moreover, the drying temperature and piece size of red peppers affects the final product quality. Temperatures higher than 60°C results in dark brown colour formation in red peppers, Red peppers that are cut into bigger pieces needs a longer time period to dry and therefore the colour of the final product are darker. Drying at low temperatures (45-50°C) for about 1 day gives good results. To increase the capacity of the solar dryer, a double layer system can be constructed, but with this system, drying needs a more careful control. Final moisture content of dried red peppers, which are pretreated with 2 Na₂S₂O₅ for 1 second, is 3.5%. The yield is 9% for both pretreated and naturally dried peppers.

Green Pepper

Green peppers are used especially in the soup manufacturing. Therefore, establishing an efficient and economic method for peppers is important for the food industry. Green peppers are washed, deseeded and cut into small pieces before loading into the dryer. Green peppers are very sensitive to high temperatures and light. Therefore, green peppers should be dried under dark and at 45-50°C to preserve the natural green colour. 2% Na₂S₂O₅ dipping for 1 sec can be applied to obtain a microbiologically safe product. Drying at 45-50°C under dark

conditions takes about 1 day. Green peppers dried under these conditions have final moisture content of 6%, and a yield of 10%.

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 semipermeable 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 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%

SO₂ (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
800g sugar
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

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 weighths remove the seeds and dry separately in the shade.
4. Blanch the tomato pieces in boiling water for 1-2 minutes.
5. Cool in drinking water and drain.
6. 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.
7. Dry until the pieces become brittle.
8. Cool and package in polyethylene or polypropylene/cellophane bags.
9. Label the bags, pack in cardboard boxes and store in a cool dry place out of direct sunlight.
10. 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.
11. The dried product can be stored for up to 1 year.





