FME - SKILL TRAINING

Drying and Dehydration of Fruits And Vegetabeles

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CONTENT

DEHYDRATION OF FRUITS AND VEGETABLES

1.0. Introduction

India ranks first in the world in production of fruits and second in vegetables, accounting roughly 10 and 15 per cent, respectively, of total global production. India have a strong and dynamic food processing sector playing a vital role in diversifying the agricultural sector, improving value addition opportunities and creating surplus food for agro-food products. Presently, 2.2 per cent of fruits and vegetables are processed, even as the country ranks second in the world in terms of production. This is comparatively low when compared to other countries like Brazil (30 per cent), USA (70 per cent) and Malaysia (82 per cent). The National policy aims to increase the percentage of food being processed in the country to 10 per cent by 2010 and 25 per cent by 2025. Food processing adds value, enhances shelf life of the perishable agro-food products and encourages crop diversification.

Fruits and vegetables with their rich contents of minerals, vitamins, dietary fiber and antioxidants are the protective foods and are considered as nature's gift for health and well-being of humans. They are highly perishable in nature due to high moisture content (70 to 95%); soft texture etc bacterial rotting by microbial respiration as well as physiological breakdown. Sometimes moisture degradation in the quality of fruits and vegetables also starts immediately after the harvest leading to drying and shrivelling. Fruits and vegetables absorb environment gasses such as oxygen and produce carbon dioxide and ethylene. They also get infested easily with microorganisms like fungi, bacteria & insects affecting food safety. In villages where fruits and vegetables are grown in plenty, facilities for processing are not in existence and lot of them are wasted. In the country the whole food processing industry is still in nascent stage and presently less than 4% of horticultural produce is being processed industrially. Though needs of preservation by drying and dehydration of fruits and vegetables are important to enhance the value of the crops.

Preservation of fruits and vegetables

Preservation means protection of foods against the spoilage, but scientifically it may be defined as a science which deals with the process for prevention of decay or spoilage of the food. In other words, controlling the physical, chemical or microbial changes in the foods is called preservation.

a. Physical Changes : Colour, flavour, texture and taste *etc.*
b. Chemical Changes : Carbohydrate, fats, proteins, vitamins and minerals *etc*.
c. Microbial Changes : Mould, yeasts and bacteria *etc*.

Need of preservation

- To increase the shelf life of the food for increasing the supply.
- To make the seasonal fruits available throughout the year.
- To add the variety to the diet.
- To save time by reducing preparation, time and energy.
- To stabilize the prices of the food in the market.
- To improve the health of the population.

Principles of Preservation

There are three main principles:

a. Prevention / delay the microbial decomposition of the food.

b. Prevention / delay the shelf decomposition of the food.

c. Prevention of damage by insects, animals, mechanical causes etc.

1.1. Methods of preservation

There are two main basic methods:

i) Bacteriostatic methods, ii) Bactericidal methods

i) Bactericidal methods:

a. Pasteurization
b. Cooking
c. Canning
d. Irradiation

ii) Bacteriostatic methods:

In this method, the environmental conditions are changed to prevent the growth of microorganisms, such conditions are called bacteriostatic. These are:

a. Drying of foods
b. Use of chemical preservatives
c. Use of food additive
d. Use of low temperature

2.0. Drying and Dehydration

The practice of drying of foodstuffs, specially fruits and vegetables, for preserving them is very old. Both the terms '**drying**' and '**dehydration**' mean the removal of water. The former term is generally used for drying under the influence of non-conventional energy sources like sun and wind.

Dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow. The drying operation for fruits and vegetables is complex mechanism as this involves simultaneous exchange of moisture and heat. The relationship between the moisture content and temperature of air during drying process is referred to as 'psychometric' relation.

Drying or dehydration removes biologically active water thus stopping the growth of microorganism. This also results in reduced rate of enzyme activity and chemical reactions. The processing should be done in such a way that the food value, natural flavour and characteristic cooking quality of the fresh material are retained after drying. Fruits are considered to be dry when they show no sign of moisture or stickiness when held firmly in the hands. Vegetable are considered to be dry when they become brittle. The residual moisture in the vegetables should not be more than 6 to 8 per cent and in fruits 10 to 20 per cent.

Aim of drying

The basic aim of drying is to reduce the biological water which is required for the growth and multiplication of microorganisms such as bacteria, fungi, mold, that causes food spoilage and decay. Since water acts as a potential vehicle for pathogens in the food chain and it has to be removed to increase the shelf life of the fruit products.

Drying and dehydration is an ideal process applicable to all food materials such as fruits, vegetable, cereals, pulses, milk, meat, fish etc to remove moisture content. Moisture is an important factor in agricultural and food materials affecting their shelf life mainly due to microbial spoilage, oxidation and breakdown of the physical structure of the foods.

Although drying seems to be a simple technique, however it is quite technical and requires a certain amount of knowledge to ensure it is carried out efficiently and safely. The mechanism of drying involves movement of moisture firstly to the surface of the food and then evaporation to the atmosphere as water vapour. For effective drying, the air should be hot, dry and moving. 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. 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.

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 kept in an airtight container for one day, then re-weighed to check if any more moisture has been lost.

Factors affecting rate of drying

Factors which should be considered while drying vary with the type of food and method of drying. Various factors that affect the rate of drying of produce include:

- Composition of raw materials
- Size, shape and stacking arrangement of produce
- Temperature, time, relative humidity and velocity of air
- Pressure (barometric or under-vacuum)
- Heat transfer to surface (conductive, convective or radiative)

Need for dehydration of food

Dehydration is meant to preserve the food for longer time and in addition to reduce bulk and weight. This reduction in weight and bulk can result in economics in transport and cost of containers. It retains the size and shape of the original food. Dehydration produces convenience items like fruit juice concentrates, fruit juice powders, soup mixes etc. The consumer can simply dehydrate the material and uses for different purpose. Many fruits and vegetables are available only during specific season, hence with the help of dehydration process it can be preserved and made available for all seasons. The biological forces acting upon foods are minimized, and spoilage of foods are easily controlled in dehydration process.

Advantages of dried fruits and vegetables

- Dried foods are in more concentrated form

- Reduction in moisture content results in reduction in weight & volume hence it increases the ease of packing, handling, storage & transport.
- There is considerable reduction in volume, requires less packing, storage place.
- Dried product has a weight only 1/4 to 1/ 9 of the fresh material
- They are less costly than foods preserved by other ways due to low cost of labour.
- Enhanced shelf life of product
- Gives the product that has characteristics suitable for further processing.
- Products have greater convenience in use.
- Dehydrated food products are particularly used for defence forces and in recent days are being manufactured for common man's use.

Advantages of dehydration over sun-drying

- The process of dehydration is much more rapid than sun-drying
- Dehydration requires less floor area and fewer trays
- Dehydration is done under very hygienic conditions
- Sun-drying is not possible during cloudy weather or during rains, whereas dehydration or mechanical drying is not dependent on the weather
- The colour of dehydrated or mechanically dried fruits and vegetables remain uniform due to uniform drying temperature.

Drying or dehydration has some advantages compared to other methods of preservation:

i) The weight of a product is reduced by $1/4^{th}$ to $1/9^{th}$ its original fresh weight and thus the cost of its transport is reduced
ii) Due to reduction in bulk of the product, it requires less storage space

3.0. Methods of Drying

i) Application of heat: a. Sun drying, b. Mechanical drying, c. Vacuum drying, d. Freeze drying;
ii) Binding the moisture in the food: a. Use of sugar, b. Use of salt.

3.1. Application of heat

Sun drying: Sun drying is the method in which food is directly exposed to sunlight. It is generally done in the places where plenty sunshine is available for long period. The dried product in this method is inferior in quality.

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.

Mechanical drying: This is a method of drying where application of heat is applied by a mechanical dryer under the controlled conditions of temperature, humidity and air flow. It is most controllable method of drying. It is also relatively 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.

Vacuum drying: The temperature of the food and the rate of water removal are controlled by regulating the degree of vacuum and intensity of heat input.

Freeze drying: In this method, the food is dried by sublimation process, *i.e.*, just converting the food into ice without passing through the liquid form of water by means of vacuum plus heat applied in the drying chamber. In this method, product is first frozen then water is removed by vacuum and application of heat which occurs simultaneously in same chamber.

3.2. Binding the moisture

Use of Sugar: The use of high concentration of sugar to bind up the free moisture which leads to lesser moisture availability in food, due to which microorganisms are not able to grow.

Use of Salt: The concentration of salt causes the high osmotic pressure and tie up the moisture which inhibit the growth of microorganisms. It dehydrates the food by drying out and tie up moisture as it dehydrates the microorganism's cells. Salt reduces the solubility of O_2 in the food by reducing the moisture. It interferes with the action of proteolytic enzyme. The effectiveness of NaCl is varied with the concentration of salt and temperature.

4.0. Types of Drying

There are 3 basic types of drying process

i) Sun and Solar drying
ii) Atmospheric dehydration including stationary or batch process and continuous process
    a. Batch processes - kiln, tower, and cabinet driers
    b. Continuous processes - tunnel, continuous belt, belt-trough, fluidized-bed, explosion puffing, foam-mat, spray, drum, and microwave-heated driers
iii) Sub atmospheric dehydration (vacuum shelf, vacuum belt, vacuum drum and freeze driers)

The scope has been expanded to include use of low temperature, low energy processes like osmotic dehydration.

4.1. Sun drying and solar drying: This includes drying of foods by use the power of the sun to remove the moisture from the product. Sun drying of crops is limited to climates with hot sun and dry atmosphere, and to certain fruits, such as prunes, grapes, dates, figs, apricots, and pears. These crops are processed in substantial quantities without much technical aid by simply spreading the fruit on the ground, racks, trays, or roofs and exposing them to the sun until dry. Advantages of this process are its simplicity and its small capital investment. Disadvantages include complete dependence on the elements and moisture levels no lower than 15 to 20 percent (corresponding to a limited shelf life). Solar drying utilizes black-painted trays, solar trays, collectors, and mirrors to increase solar energy and accelerate drying.

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 meter 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.

4.2. Atmospheric forced-air drying: Atmospheric forced-air driers artificially dry vegetables by passing heated air with controlled relative humidity over the food to be dried, or by passing the food to be dried through the heated air, and are the most widely used method of vegetable dehydration. Various devices are used to control air circulation and recirculation. Stationary or batch processes include kiln, tower (or stack), and cabinet driers. Continuous processes are used mainly for vegetable dehydration and include tunnel, continuous belt, belt-trough, fluidized-bed, explosion puffing, foam-mat, spray, drum, and microwave-heated driers. Tunnel driers are the most flexible, efficient, and widely used dehydration system available commercially.

4.3. Sub atmospheric dehydration: Sub atmospheric (or vacuum) dehydration occurs at low air pressures and includes vacuum shelf, vacuum drum, vacuum belt, and freeze driers. The main purpose of vacuum drying is to enable the removal of moisture at less than the boiling point under ambient conditions. Because of the high installation and operating costs of vacuum driers, this process is used for drying raw material that may deteriorate as a result of oxidation or may be modified chemically as a result of exposure to air at elevated temperatures. There are two categories of vacuum driers. In the first category, moisture in the food is evaporated from the liquid to the vapour stage, and includes vacuum shelf, vacuum drum, and vacuum belt driers. In the second category of vacuum driers, the moisture of the food is removed from the product by sublimination, which is converting ice directly into water vapour. The advantages of freeze drying are high flavour retention, maximum retention of nutritional value, minimal damage to the product texture and structure, little change in product shape and color, and a finished product with an open structure that allows fast and complete rehydration. Disadvantages include high capital investment, high processing costs, and the need for special packing to avoid oxidation and moisture gain in the finished product.

Solar Dryer

Solar Hybrid Dryer

Fluidized Bed Dryer

Tray Dryer

Drum Dryer

Three-tier Deck Dryer

Spray Dryer

Radio-frequency Dryer

5.0. Pre-drying Treatments

Pre-drying treatments prepare the raw product for drying or dehydration and include raw product preparation and color preservation. Raw product preparation includes selection and sorting, washing, peeling (some fruits and vegetables), cutting into the appropriate form, and blanching (for some vegetables). Vegetables are selected; sorted according to size, maturity, and soundness; and then washed to remove dust, dirt, insect matter, mold spores, plant parts, and other material that might contaminate or affect the color, aroma, or flavour of the vegetable. Peeling or removal of any undesirable parts follows washing. The raw product can be peeled by hand with lye or alkali solution, with dry caustic and mild abrasion, with steam pressure, with high-pressure washers, or with flame peelers. For fruits, only apples, pears, bananas, and pineapples are usually peeled before dehydration. Vegetables normally peeled include beets, carrots, parsnips, potatoes, onions, and garlic. Next, the product is cut into the appropriate shape or form (i. e., halves, wedges, slices, cubes, nuggets, etc.). Some vegetables are blanched by immersion in hot water (95 to 100 ^{o}C [203 to 212 ^{o}F]) or exposure to steam. Most vegetables (potatoes, cabbage, and carrots) are treated with sulphite solutions to retard enzymatic browning. In addition to color preservation, the presence of a small amount of sulphite in blanched, cut vegetables improves storage stability and makes it possible to increase the drying temperature during dehydration, thus decreasing drying time and increasing the drier capacity without exceeding the tolerance for heat damage.

- **Blanching:** Only for vegetables except onion and garlic. Fruits are not blanched but thick skinned fruits are sometimes lye-peeled to 'check' the skin or to remove the peel to facilitate drying e.g. peaches.
- **Sulphuring:** Sulphur dioxide fumes act as a disinfectant and prevent the oxidation and darkening of fruits on exposure and thus improves their colour. Vegetables are not generally sulphured. Whole fruit, slices or pieces are exposed to the fumes of burning sulphur inside a closed chamber known as sulphur box for 30 to 60 min.
- **Sweating/Conditioning:** Keep dried products in jars or bins to equalize moisture content. Conditioning reduces the chance of spoilage, particularly from mold. To condition, loosely pack cooled, dried fruit in plastic or glass containers to about two-thirds full. Cover the containers tightly. Shake them daily for about 2 to 4 days. The excess moisture in some pieces will be absorbed by the drier pieces. If you notice water forming on the container lid, place the fruit back in the dehydrator. Because vegetables dry to a nearly waterless state, conditioning vegetables is not necessary.

6.0. Post-dehydration Treatments

Treatments of the dehydrated product vary according to the type of vegetable and the intended use of the product. These treatments may include sweating, screening, inspection, instantiation treatments, and packaging. Sweating involves holding the dehydrated product in bins or boxes to equalize the moisture content. Screening removes dehydrated pieces of unwanted size, usually called "fines". The dried product is inspected to remove foreign materials, discoloured pieces, or other imperfections such as skin, carpel, or stem particles. Instantiation treatments are used to improve the rehydration rate of the low-moisture product. Packaging is common to all most all dehydrated products and has a great deal of influence on the shelf life of the dried product. Packaging of dehydrated vegetables must protect the product against moisture, light, air, dust, micro flora, foreign odour, insects, and rodents; provide strength and stability to maintain original product size, shape, and appearance throughout storage, handling, and marketing; and consist of materials that are approved for contact with food. Cost is also an important factor in packaging. Package types include cans, plastic bags, drums, bins, and cartons, and depend on the end-use of the product.

Schedule for drying of fruits

Fruits	Preparation & Pre-treatment	Time of Sulphuring (min)	Drying Temp. (°C) &Time	Drying Ratio
Apple	Wash, peel, core trim and cut in to 5mm thick slices	30 min or immerse in 1-2% KMS solution for 30 min	60-65 °C 6-10 hrs	8:1

		and drain		
Apricot	Wash, halve, destine	30 min	50-60 °C 10-12 hrs	6:1
Banana	Wash, peel, halve lengthwise or slice crosswise 12 mm thick	30 min	55-60 °C 18-20 hrs	6:1
Date	Wash, dip in boiling 0.5% caustic soda solution, then rinse	-	45-50°C	6:1
Fig	Wash	1 hour	55-60 °C	6:1
Grape	Dip in boiling 0.5% caustic soda solution, and then rinse.	1 hour	55-60 °C 20-30 hrs	5:1
Mango	Wash, peel and cut into 12 mm thick slices	2 hours	45-50 °C 10-12 hrs	6:1
Papaya	Wash, peel, remove seeds and cut in to 6mm thick slices	2 hours	60-65 °C 10-12 hrs	8:1
Peach	Wash, remove pits, cut into halves.	30 min	60-65°C 15-20 hrs	6:1
Pear	Wash, peel, cut into halves, remove core, keep in 1-2 % salt solution	30 min or immerse for 20-30 min in 1-2% KMS solution for 30 min and drain	60-65°C 15-24 hrs	6:1

Schedule for drying of vegetables

Vegetables	**Preparation & Pre-treatment**	**Time of Sulphuring (min)**	**Drying Temp. (°C) &Time**	**Drying Ratio**
Beans	Wash and remove strings, split pods lengthwise	Blanch for 4-5 min	60-65°C 8-10 hrs	7:1
Beet	Wash, peel and cut in to 10mm thick slices	Steam for 10 min	60-65°C 14-16 hrs	18:1
Bitter gourd	Wash, remove both ends and cut into 10mm thick slices	Blanch for 7-8 min	65-70°C 7-9 hrs	16:1
Brinjal	Wash, cut lengthwise into 10mm thick slices	Blanch for 4-5 min and then immerse for 1 hour in 1% KMS solution	50-52°C 7-10 hrs	16:1
Cabbage	Wash, remove outer leaves and core, cut into fine shreds	Blanch 5-6min, immerse for 10 min in 0.5% KMS solution and drain	50-55 °C 12-14 hrs	18:1
Chillies	String mature dark red pods and hang in sun	No treatment	50-55°C	16:1
Carrot	Wash, scrape stalks and tips, cut into 10mm thick slices	Blanch for 2-4 min in boiling 2% common salt solution	60-65°C 14-16 hrs	18:1
Cauliflower	Wash, remove stalks covering leaves and stems break flowers apart into	Blanch 4-5 min, immerse for 1hour in 1% KMS solution and drain	55-60°C 10-12 hrs	35:1

	pieces of suitable size.			
Green peas	Wash, remove shell and collect the grains	Blanch or stem for 3-4 min, immerse in 0.5% KMS solution and drain	60-65°C 8-10 hrs	8:1
Onion	Remove outer dry scales, cut into 5mm thick slices	Dip for 10 min in 5% salt solution and drain	60-65°C 11- 13 hrs	10:1
Garlic	Peel the clove, use as such or cut in to 5mm thick slices	Dip for 10 min in 5% salt solution and drain	60-65°C 7-8 hrs	6:1
Palak, methi, other GLV	Sort, wash, trim off rough stems and stalks, shred.	Blanch for 2 min in boiling water or steam	50-55°C 11-13 hrs	28:1
Potato	Wash, peel and cut into 10mm thick slices	Blanch in boiling water or steam for 3-4 min and immerse in 0.5% KMS solution	60-65°C 7-8 hrs	18:1
Pumpkin	Cut into 50-75 mm. wide longitudinal strips, peel, remove the seeds and soft portions in contact with the seeds, prick uniformly using a stainless steel fork and cut into 6. cubes	Blanch in steam for 10 minutes	60-65°C 9-10 hrs	28:1
Spinach	Sort, wash thoroughly and cut into 10-12 mm. portions using a stainless steel knife	Blanch as above for 2 minutes	50-55°C 11-13 hrs	28:1
Split field beans	De-skin and split whole bean (Dolichos) seeds by boiling in 1 % sodium carbonate solution for 5-7 minutes and rubbing off the skin under a spray of water	Blanch as above for 2 minutes	60-65°C 8-10 hrs	7:1
Tomato	Wash	Blanch for 30-60 seconds, peel and slice 10 mm thick	60-65°C 9-10 hrs	27:1
Turnip	Wash, remove stalks, peel and cut in to 5mm thick slices.	Blanch for 2-4 min in boiling water and then immerse for 1-2 hours in 1% KMS solution	50-55°C 11-13 hrs	28:1
Okra (sliced)	Remove both ends with stainless steel knife and cut into 6 mm. thick slices	Blanch in boiling water for 4-5 minutes and sulphite in 0.25 % KMS solution for 10 minutes using 0.5 kg. solution per kg. of slices	50-55 °C 12-14 hrs	18:1
Okra (small-sized 50-75 mm. length, whole)	Remove stalks with stainless steel knife and slit longitudinally along the ridges	Blanch in boiling water for 6-7 minutes	50-55 °C 12-14 hrs	18:1

Srivastava and Kumar (1998)

7.0. Osmotic Dehydration

Osmotic dehydration is a useful technique for the concentration of vegetables, by placing the solid food, whole or in pieces, in sugars or salts aqueous solutions of high osmotic pressure. It gives rise to at least two major simultaneous counter-current flows: a significant water flow out of the food into the solution and a transfer of solute from the solution into the food. Main process variables are:

a. Pre-treatments
b. Temperature
c. Nature and concentration of the dehydration solutions
d. Agitation
e. Additives

8.0. Reconstitution of Dehydrated Fruits and Vegetables

Dried fruits and vegetables may be reconstituted (restoring moisture) by soaking in water). Time for reconstituting will depend on the size and shape of the food and the food itself. Generally most dried fruits can be reconstituted within 8 hours, whereas most dried vegetables take 2 hours to be reconstituted. To prevent growth of microorganisms, dried fruits and vegetables should be reconstituted in the refrigerator. One cup of dried fruit will yield approximately 1 ½ cups of reconstituted fruit. One cup of dried vegetable will yield approximately 2 cups of reconstituted vegetable. Reconstituted fruits and vegetables should be cooked in the water in which they were soaked.

9.0 Packing for dehydrated fruits and vegetables

Good packaging and storage techniques are crucial. Packaging protects your dried food from oxygen, moisture (gain or loss), light, microorganisms, and pests. After you have checked foods and found them to be thoroughly dry and cool, pack them immediately for storage. Packing is the most vital steps for the success of the dehydration industry. Dried fruits and vegetables should be dry and should be packed in moisture proof containers. Tin containers or bottles are most suitable for it, but nowadays it is replaced by various types of plastic packing.

9.1. Ideal packing materials

The three important types of packing materials *via.*, glass, plastics and metal (Never galvanized steel) are used for packing most dried foods. Even open-and-close plastic bags, Polyvinylidene chloride coated polypropylene-polyethylene, Cellulose-acetate-paper-foil- polyethylene and Polyethylene-aluminium-paper are suitable. Containers made of tin plate; laminated foil bags and metallised BOPP/LDPE bags are suitable for dehydrated vegetables.

Thermoplastics for food contact applications

Food Product	Thermoplastics that may be used in contact with food	Most common form of usage	Normal Combination, if any, with other Substrates
Dehydrated fruits and vegetables	LDPE, PP	Pouches	Laminated to foil
Atmospheric freeze dried vegetables	LDPE, EVA	Pouches	Laminated to foil
Dehydrated fruits	LDPE, PP, HDPE NC PVDC	Bags Bags	None Coated on cellophane
Dehydrated vegetables	HDPE	Bags	None

The ideal packing materials should have all these following characteristics to retaining the quality of dehydrated fruits and vegetables.

i) Clean and sanitary
ii) Nontoxic
iii) Lightweight
iv) Easily disposable or recyclable
v) Moisture resistant
vi) Airtight
vii) Protective against light
viii) Easily opened and closed
ix) Impermeable to gases and odors
x) Durable
xi) Low-cost

Unfortunately, no single container or materials has all these characteristics. Choices should be made based on the type of dried food, its intended storage conditions and storage time. Dried food should be stored in a cool, dry, dark place. Most dried fruits can be stored for 1 year at 60° F, 6 months at 80° F. Dried vegetables have about half the shelf-life of fruits. Fruit leathers should keep for up to 1 month at room temperature. To store any dried product longer, place it in the freezer.

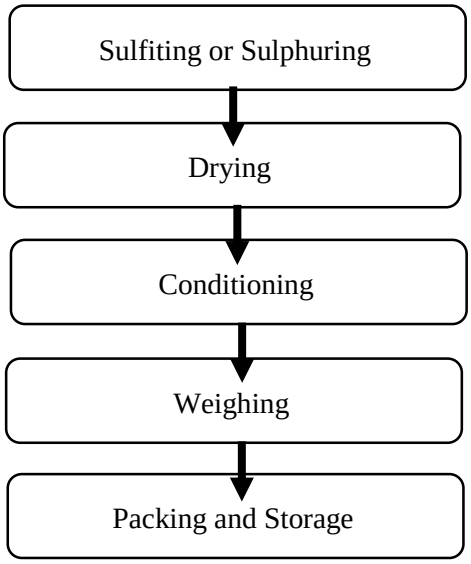
10.0. Manufacturing of Dried Vegetable

The vegetable dehydration technique is reasonably simple and consists of exposing the food to the sun or to place it in appropriate dryers for removing a high water amount contained in the product. The dehydration preserves the vegetable because it reduces its moisture content, therefore avoiding or limiting the microorganism growths and chemical reactions. The removal of the water facilitates the transport, the

storage and the management of the final product, no matter it is assigned to direct consumption or as ingredient in elaborating other nutritive products.

The dehydration technique concentrates mineral salts and other components such as the sugars found in the vegetables, besides enhancing their flavor. When accomplishing this technique, some losses of vitamins rather occurs because they are sensitive to the heat. The dehydrated high-qualified vegetables should present the following characteristics: low moisture content, around 5%; absence of defects caused by the use of inappropriate raw material; a fast and satisfactory re-hydration, by assuming the shape and original appearance of the product before its drying. The main deterioration factors in the dehydrated vegetables are: lipid oxidation reactions; non-enzymatic darkening; oxidation of vitamins (C and B) and pigments, such as chlorophyll and carotenes. The microbiological, sensorial and physiochemical analyses should be extensively used for the warranty of the quality in the dehydrated final product.

Flow sheet for dried vegetable production



- **Sulfiting or Sulphuring :** The main deterioration factors in the dehydrated vegetables are: lipid oxidation reactions; non-enzymatic darkening; oxidation of vitamins (C and B) and pigments, such as chlorophyll and carotenes. The microbiological, sensorial and physiochemical analyses should be extensively used for the warranty of the quality in the dehydrated final product. Sulphuration should be accomplished within hermetic chambers in order for the distribution of gas on the vegetable surface to be the most uniform as possible. The residual content of the free SO_2 should not surpass 100 ppm or 100mg/kg product (w.b.). For immersion into sulfite solution, the vegetables are dipped into sodium bisulfite solution from 1 to 2%.

- **Drying:** The drying of the vegetables may be accomplished either by direct exposure to the sun or indirect heating systems, by using the air as simultaneous- action element for transportation of the heat and the water vapor removed from the vegetable. The drying temperature ranges from 40 to 70°C and the drying time may range from 2 to 24 hours, as depending on the way the material is arranged for drying. The drying by direct exposure to the sun is still widely practiced. However, its use is limited to the regions with hot and dry climate and high insolation. Drying is divided into two stages: in the first one, the vegetables are uniformly distributed on a tray, and are exposed to the sun until losing from 50 to 70% moisture. In the second one, the vegetables are taken to the shadow in order to avoid dryness and loss of the characteristic aroma and flavor. In the indirect system, the heat is transmitted to the vegetable through the hot air that circulates tangentially to the product under a horizontal or transverse flow. The time and drying temperature depend on the type and shape of the raw material, air relative humidity, air speed within the cabinet and the characteristics of the equipment. For small and medium enterprises, the most suitable dryers are the cabinets and the continuous belts, as the first ones presenting lower cost.
- **Conditioning:** Many times the location inside the dryer or even the size and shape of the vegetal parts hinder the water loss from occurring equally during drying. The conditioning allows for an uniform distribution of this residual moisture. This procedure consists of conditioning the product into a recipient, by occupying only two thirds of its volume, and sealing it. The product should remain under conditioning during two to five days. In this period, it must be moved at regular intervals. The excess moisture contained in a part of the vegetable will be absorbed by the drier part, hence reaching the equilibrium.
- **Weighting:** When the conditioning phase is over, the weighting and calculation of the total product obtained from the dehydration process are accomplished. Some care should be taken to avoid shortage of products in the package. The total amount of product in each package will depend on the chosen package that is glass pot, plastic pot or plastic package.
- **Packaging:** The dehydrated vegetables contain a low moisture content. The packaging should preserve the characteristics of that product it contains. It should not allow the absorption of external moisture. The vegetables should be packed at small quantities inside polypropylene 25mm - thick bags that are tightly sealed. Before sealing, the air must be removed from the packaging. The vacuum packaging improves the conservation of quality in the dehydrated vegetables. The undulated cardboard boxes are recommended to secondary packaging. In these recipients, silica gel, a chemical which absorbs the air humidity is usually introduced, so as to prolong the storage time.

- **Storage:** The dehydrated vegetables should be stored in fresh places that are protected against light and air humidity. The light changes the vegetable color, besides causing the loss of the vitamins A and C. The heating reduces the life time of the product.

The following lists of vegetables are dehydrated are as given below:

Vegetables	**Method of preparation**
Dried ginger	The ginger is first soaked in water overnight. Then they are thoroughly washed in water. After thoroughly cleaning, the outer skin is removed carefully with a split of bamboo knife/wooden scrapers to preserve the pleasing aroma in dried ginger. The scraped ginger is cut into pieces and spread in a tray at a rate of 5Jg/sqm in solar dryer. This process can be continued for 2 sunny days (16 hrs) in a solar dryer. The dried ginger is again ground into powder form and is well packed in a suitable DPE pouches. The initial moisture content of ginger was about 80.9% and the final moisture content should be 4% or less. The yield of dry ginger should be 16-25% of wet weight.
Dehydrated garlic	At the end of the dehydration process, this product exhibits a yellow to yellow dark coloration. This is due to the sugar-caramelizing reaction, when the vegetable is subjected to higher temperatures. The product should be shown under the shape of small cubes or fine slices. The moisture content should be lower than 12% (w.b).
Dried yams	After washing and peeling, cut the tubers into slices and dip them in to cold water to avoid browning). The slices are cut in pieces of about 2 X I - I cm. For preservation purposes and to keep the colour of the tuber blanching is carried out wrapped in a clean piece of cloth, yams are dipped in boiling water containing. 50 g salt per litre of water and 3 g metabisulphite per litre of water Then drain the product and arrange the pieces on the trays of a drier the yam is dried when the prepared raw material/dry product ratio is about 12:1 (moisture content 6 %). Storage life: About 12 months.
Dried lady's finger	The pods are cut into slices (around 5 mm. thick) after being washed thoroughly with cold water. For preservation purposes and in order to keep the green colour, blanching is carried out: wrapped in a clean piece of cloth' the product is dipped for 3 minutes in boiling water containing 50 g salt per litre of water and 3 g potassium meta-bi-sulphite per litre of water. The blanched okras can then he washed with cold water to remove the slimy material produced by boiling. The product is then

	drained and finally placed on the trays of a drier. The prepared raw material/dry products ratio is about 12:1 (moisture content 4 - 5 %). Storage life: About 12 months.
Dried green beans	After washing, cut the vegetables into 5 cm - long pieces. For preservation purposes and in order to keep the colour of the vegetable, blanching is carried out: wrapped in a clean piece of cloth, the product is dipped in boiling water containing 50 g salt per litre of water and 3g metabisulphite ($K_2S_2O_5$) per litre of water. Then drain and spread the beans on the trays of a drier. The beans are dried when the prepared raw material/dry product ratio is about 7:1 (moisture content 6 %). Storage life: About 12 months.
Cauliflower drying	After destalking and cutting the cauliflower is wash properly. Following the cleaning process it is blanched in boiling water. The recommended pre-treatments are i) Sodium Chloride (0.5, 1.0 & 1.5%), ii) Potassium Metabisulphite (0.5, 1.0 & 1.5%) and iii) Sodium Benzoate (0.5, 1.0 & 1.5%). Then the solute is drained well and dried on a tray drier. Dried samples can be packed in Poly propylene, High density polyethylene or Laminated foil pouches.
Dried cabbages	After removing the outer leaves, the vegetable is washed and cut into quarters. Cores are removed and the cabbages are cut into 5 mm strips. It is then washed to get rid of dust' soil and insects. To keep the colour of the vegetable and for preservation purposes, blanching is carried out: wrapped in a clean piece of cloth, the product is dipped for 3 minutes in boiling water containing 50 g salt per litre of water and 3 g potassium metabisulphite per litre of water. The product is then evenly spread on the trays of a drier. The cabbages are dry when the prepared raw material/dry product ratio is around 18:1 (moisture content 5 %). Storage life: About 12 months.
Dried onions	Varieties with pungent flavour are the most appreciated but troth coloured and white onions may be used. After removing the tops, roots and outer integuments, onions are washed carefully then cut in to slices of 3 to 5 mm thick. It is preferable to cut at right angles to the core of the onion. Blanching is not practiced (it makes the onion lose its flavour). The use of preservatives is not necessary; therefore, after cutting, the slices arc spread evenly on the trays of a drier. The onions are dried when the ratio of prepared raw material to dry product is about 10:1 (moisture content 5 %). The dried product may be ground into powder, which

	tends to agglutinate. The drier used for onions must be reserved especially for onions. Storage life: About 12 months.
Dried carrots	Roots with red cores are the best for drying. After removing the stalks and tips, wash the carrot, scrape, then cut in to slices of about 5 mm thick. For preservation purposes and in order to keep the colour of the vegetable, blanching is necessary: wrapped in a clean piece of cloth, the slices are dipped for 3 minutes in boiling water contain" 50 g salt per litre of water and 3 g metabisulphite per litre of water. The product is then evenly spread on the trays of a drier. The carrots are dried when the prepared raw material/dry product ratio is about 12:1 (moisture content 6 %). Storage life: About 12 months.
Dehydrated green pepper	At the end of the dehydration process, this product presents dark green coloration. It should be shown under the shape of small cubes. The moisture content should be lower than 12% (w.b.)

Vegetable soup

This product is constituted by a mix of the other four industrialized products, and it serves as basis for the constitution of a soup. So, the mix should contain the vegetables at the following proportions:

31,8% of dehydrated onion

31,8% of dehydrated carrot

31,8% of dehydrated green pepper

4,60% of dehydrated garlic

The mix for soup is a product used as ingredient to compose a completely dehydrated soup. To do so, it would be necessary that the proposed mix to be added with the ingredients listed below, at the following proportions:

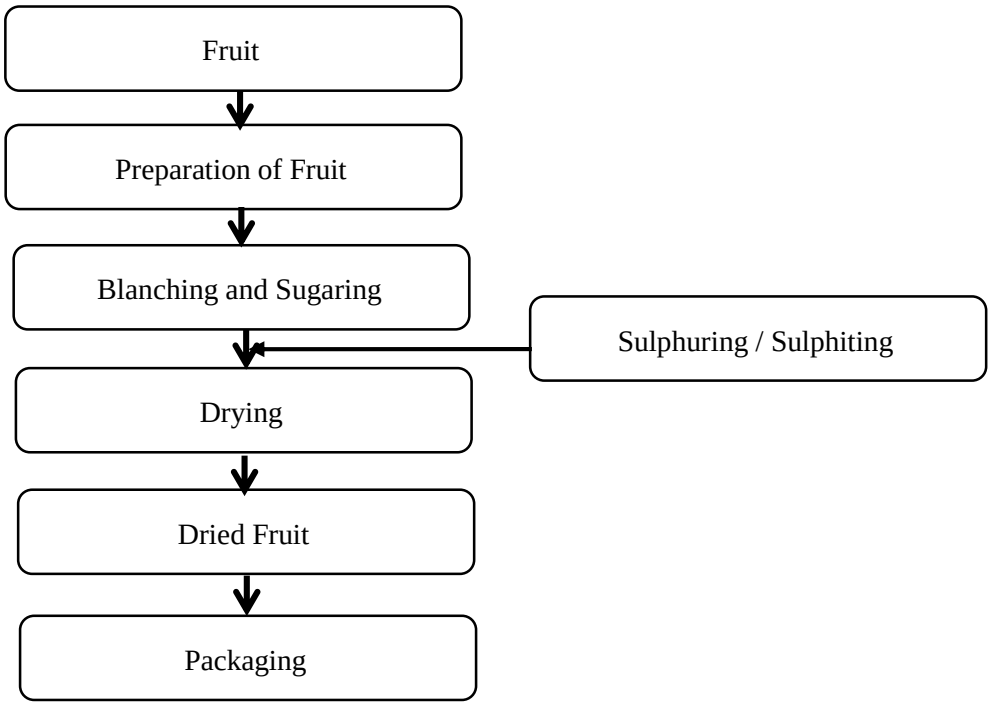
Ingredient	Weight (g)	Percentage (%)
Mix for soup	11	11%
Tomato	3,5	4%
Garden Parsley	0,25	0.3%
Meat	8,5	9%
Black pepper	0,25	0.3%
Corn starch	6,5	7%
Maltodextrin	3,5	4%
Meat extract	2	2%
MSG	3,5	4%
Soy Texturized Protein	4	4%

Vegetal fat	2	2%
Salt	5	5%
Macaroni	50	50%

11.0 Manufacturing of Dried Fruit

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.

Process flow sheet for drying of fruits



- **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 thiner 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. Only stainless steel knives should be used to peel and chop the fruit. Other metals will discolour the fruit flesh.

  Recommended slice thickness for various fruits:

Fruits	**Thickness**
Pineapple	2-3mm
Mango	6-8mm
Banana	5mm
Tomato	3-5mm

- **Blanching:** 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.

- **Sugaring fruit for drying:** 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.
- 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.
- **Preparation of sugar solution (syrup):** 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.

- **Sulphuring or Sulphiting** Sulphuring or sulphiting is an optional stage of processing. Sulphur dioxide is used to preserve the colour and increase the shelf life of dried foods. There are two main methods of adding sulphur to foods - sulphuring and sulphiting. Sulphuring is more common for fruits and sulphiting for vegetables. Sulphuring uses rock sulphur which may be more readily available than sodium or potassium metabisulphite. One of the disadvantages of sulphiting is that it wets the fruit (the fruit is dipped into a solution of metabisulphite). This prolongs the drying period required. The main benefit of sulphuring is to preserve the fruit colour. Some consumers object to chemical preservatives and prefer naturally dried fruits. Sulphuring involves burning elemental sulphur in an enclosed chamber. Sulphur dioxide gas is given off, which is absorbed by the food. The sulphur chamber is either a cabinet or tent in which perforated trays are stacked on top of each other. Food is placed on the trays inside the cabinet. The sulphur is placed in a box close to the trays and allowed to burn for 1-3 hours. A simple sulphur tent can be made from a rack of shelves that are covered with an airtight polythene sheet. It is essential that the cover does not have holes and that it is firmly anchored down at the ground to prevent sulphur dioxide gas from escaping. Sulphur dioxide gas (SO_2) 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. The amount of sulphur used and the time of exposure depend on the commodity, its moisture content, the sizes of the pieces and the permitted final levels in the product. For most fruits, 5-6g sulphur per kg food is adequate. For most vegetables, 10-12g sulphur per kg food is sufficient. The Sulphur dioxide gas given off is toxic and corrosive. Therefore, sulphuring should be carried out in a well-ventilated place, the cabinet used for sulphuring should not be made of metal, using outdoor cabinet is preferably as the fumes of burning sulphur are unpleasant and can be dangerous if inhaled. Wooden or plastic-coated metal shelves should be used within a wooden cabinet or a polythene tent. Sulphite can be included in the sugar syrup, 0.5 to 1g potassium metabisulphite per kg fruit is required if colored fruits and vegetables metabisulphite is preferable.
- **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).

- **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.

The following lists of various fruits are dehydrated are as discussed below:

Fruits	**Method of preparation**
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_2 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.
Bread fruit	Peel, core and cut into ships or thin slices. Follow the same method as for bananas.
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.
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.
Peaches	Peel carefully and avoid bruising. Dry as for pears until pliable but leathery.
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
Plums	Cut in half and remove the stone. Either check or blanch the fruits, then sulphur for 60 minutes. Dry the same as apricots.
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.
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.
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.
Tomatoes	Select unblemished ripe tomatoes of a uniform colour. Wash in clean water and leave to drain. Remove the stalk. Cut the tomatoes lengthwise into quarters or eighths. Remove the seeds and dry separately in the shade. Blanch the tomato pieces in boiling water for 1-2 minutes. Cool in drinking water and drain. Immerse in a solution of sodium metabisulphitem (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. Dry until the pieces become brittle. Cool and package in polyethylene or polypropylene/cellophane bags. Label the bags, pack in cardboard boxes and store in a cool dry place out of direct sunlight. 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. The dried product can be stored for up to 1 year.
Mango	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.
Osmo-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 700-800g sugar (to make a 40°Brix solution) potassium metabisulphite (3g per litre of water) lemon juice (10-20ml 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.
Papaya	Dry as for mango.

Practical aspects of dehydrated fruits and vegetables

i) 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, minimize 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.

ii) 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.

Case Hardening: 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.

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

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 :

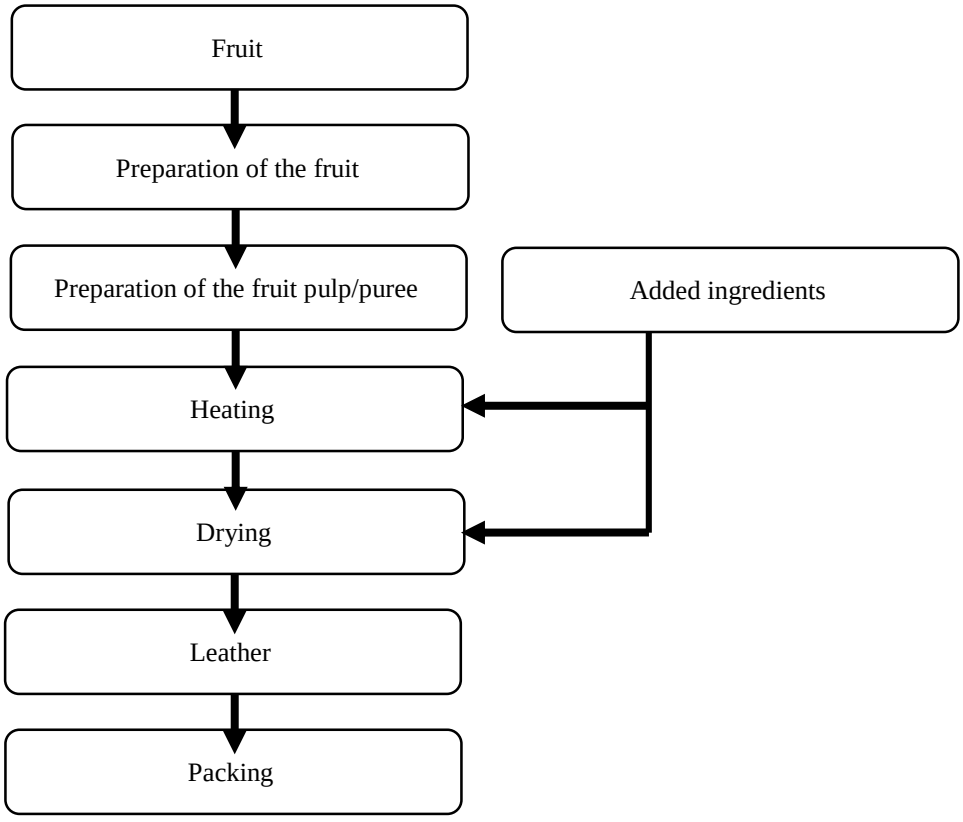
Fruit	<20%
Vegetables	<10%

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.

12.0. Manufacturing of Fruit Leathers

Fruit leathers are dried sheets of fruit pulp which have a soft, rubbery texture and a sweet taste. They can be made from most fruits, although mango, apricot, banana and tamarind leathers are amongst the most popular. Leathers can also be made from a mixture of fruits. Fruit leathers are eaten as snack foods instead of boiled sweets. They are also used as ingredients in the manufacture of cookies, cakes and ice cream. The preservation of fruit leathers depends on their low moisture content (15-25%), the natural acidity of the fruit and the high sugar content. When properly dried and packaged, fruit leathers have a shelf life of up to 9 months.

Process flow sheet for fruit leather production



- **Preparation of the fruit:** Fruit should be washed in clean water, peeled and the stones removed. Washing water can be chlorinated by adding 1 teaspoon of bleach to 4.5 litres of water. All fruit should be ripe and free from bruising. Any rotten or bruised fruit should be thrown away as this will spoil the colour and flavour of the leather. Pineapple contains an enzyme that damages the skin. Therefore, gloves should be worn when handling pineapple. The puree must be heated to a higher temperature for a longer time to destroy the enzyme (it must be boiled for 20 minutes). 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. Soft fruit, such as berries and apricots, are delicate and should be handled carefully to avoid bruising. Only stainless steel knives should be used to chop the fruit. Other metals will discolour the fruit flesh.
- **Preparation of the fruit:** Pulp/puree At the simplest level, fruit is made into a puree by hand using a food mill or mouli legume. If electricity is available, a liquidiser or blender can be used to increase the production output. The liquidised fruit is strained or sieved to remove fibres, seeds etc and make a smooth puree. Fruit puree can be semi-processed and stored in sealed drums for further processing later in the season. Sulphur dioxide (SO2) (600ppm) is added to the drums to prevent the growth of micro-organisms. The semi-processed fruit can be stored for several month.
- **Added Ingredients:** Chemical preservatives may be added to the fruit puree to maintain a bright colour in the leather. Preservatives are also added if the puree is to be stored before processing. A variety of ingredients can be added to the fruit puree - sugar to increase the sweetness, citric acid to increase the acidity and chopped nuts, coconut or spices to vary the taste and flavour.
- **Heating** The puree must be heated to 90deg C to inactivate the enzymes and reduce the level of microbiological contamination. A double pan boiler is recommended for heating to avoid burning the puree.
- **Drying:** The fruit puree is poured in a thin layer (3-6mm thick) on plastic trays or wooden trays lined with greaseproof paper. The puree can be poured into a square which is later cut into small pieces, or into small circles which are rolled up when dry. The leathers should not be dried in direct sunlight as this will cause the colour to fade and reduce the levels of vitamins A and C. Indirect solar dryers or mechanical dryers should be used. The leather should be dried overnight in a solar dryer or for about 5 hours in a mechanical dryer. After this time it is turned over and dried on the other side. The leather is dried until it has a final moisture content of 15-25%. After drying, the leather pieces should be dusted lightly with starch to prevent them sticking together.
- **Packaging:** Fruit leather is usually sold as a roll that is interleaved with greaseproof paper to prevent it from sticking together. Strips of the leather are weighed, laid on a piece of greaseproof

paper and rolled with the paper. The rolls or discs of leather are packed in polythene or polypropylene heat-sealed bags. The bags should be placed in boxes to protect them from the light.

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

Mango Leather

Fully ripe mango (the pulp weight according to the variety used and consumer taste), Sugar 10-15%, Lemon juice or citric acid 10ml per kg pulp, Sodium of potassium metabisulphite 2g per kg pulp, Glycerine for foods

- Wash the mangoes in clean water. Drain. Sort and remove any unripe or over-ripe fruit.
- Peel the fruit with a stainless steel knife and cut the flesh into small pieces.
- Extract the pulp using a pulper.
- Weigh the pulp and mix with the sugar, lemon juice and metabisulphite in the ratios above.
- Heat at 70-80°C until a final solids content of %.
- Remove the foam from the top of the mixture. Grease the surface of trays with glycerine to prevent the leather from sticking.
- Pour the hot puree onto the trays at a ratio of 15kg per square metre of tray area.
- Place the trays in a solar dryer. Leave to dry until a final moisture content of 15%. The product will have a soft, leather-like consistency.
- Place three sheets of leather on top of each other and cut into small 4x4cm squares. Wrap each square in cellophane. It may be necessary to dust the squares with cornflour to prevent excess stickiness.
- Pack in plastic bags, label and store in a cool dry place.

Practical aspects of dried leather

Each batch of leather is prepared the same way to ensure consistency of quality. The flavour of fruit leather is improved by adding lime or lemon juice to the puree to increase the acidity. This also helps with preservation. The fruit may be mixed with semi-ripe banana pulp, which increases the level of solids in the mix. This reduces the cost of the product and reduces the drying time. Other ingredients, such as sugar and nuts may also be added according to taste. The following basic recipes are only guidelines since they depend on the composition of fruit (which varies between different types) and the different consumer tastes for sweetness.

FOOD SAFETY AND STANDARDS REGULATIONS

Regulation 5.3.19 Fruit Bar/ Toffee:

1. Fruit Bar/ Toffee means the product prepared by blending Pulp/Puree from sound ripe fruit, fresh or previously preserved, nutritive sweeteners, butter or other edible vegetable fat or milk solids and other ingredients appropriate to the product & dehydrated to form sheet which can be cut to desired shape or size.

2. The product may contain food additives permitted in Appendix A. The product shall conform to the microbiological requirements given in Appendix B. The product shall comply with the following requirements:-

i)	Moisture (m/m)	Not more than 20.0 percent
ii)	Total soluble solids (m/m)	Not less than 75.0 percent
iii)	Fruit content (m/m)	Not less than 25.0 percent

Regulation 5.3.20 Fruit/Vegetable:

1. Fruit/Vegetable means the product prepared by blending fruit(s) Pulp/Puree of sound ripe fruit(s) / vegetables of any suitable variety, fresh, frozen or previously preserved, starch, cereals & nutritive sweeteners, other ingredients appropriate to the product with or without salt & dehydrated in the form of flakes.

2. The product may contain food additives permitted in Appendix A. The product shall conform to the microbiological requirements given in Appendix B. The product shall comply with the following requirements:-

i)	Moisture (m/m)	Not more than 6.0 percent
ii)	Total soluble solids (m/m)	Not more than 0.5 percent
iii)	Fruit content (m/m)	Not more than 25.0 percent

Regulation 5.3.24 Murabba

1. **Murabba** means the product, prepared from suitable, sound whole or cut grated fruits, rhizome or vegetables, appropriately prepared, suitable for the purpose, singly or in combination, by impregnating it, with nutritive sweeteners to a concentration adequate to preserve it.

2. The product may contain food additives permitted in Appendix A. The product shall conform to the microbiological requirements given in Appendix B. The product shall conform to the following composition:

(i) Total soluble solids (m/m) Not less than 65.0 percent (ii) Fruit contents (m/m) Not less than 55.0 percent

i)	Total soluble solids (m/m)	Not less than 65.0 percent
ii)	Fruit content (m/m)	Not less than 55.0 percent

3. The container shall be well filled with the product and shall occupy not less than 90.0 percent of the water capacity of the container, when packed in the rigid containers. The water capacity of the container is the volume of distilled water at 20ºC which the sealed container is capable of holding when completely filled.

Regulation 5.3.25 Candied, Crystallised And Glazed Fruit / Vegetable / Rhizome / Fruit Peel:

1.1 Candied Fruits / Vegetables/ Rhizome / Fruit Peel means the product prepared from sound and ripe fruits, vegetables, rhizomes or fruit peel, of any suitable variety, appropriately prepared, by impregnating it with nutritive sweeteners to a concentration adequate to preserve it.

1.2 Crystallised Fruit / Vegetable/ Rhizome / Fruit Peel means the product prepared from candied product by coating with pure crystallised sugar or by drying the syrup on wet candied fruit.

1.3 Glazed Fruit/ Vegetable/Rhizome / Fruit Peel means the product prepared from candied product by coating it with a thin transparent layer of heavy syrup with or without pectin which has dried to a more or less firm texture on the product.

2. The product may contain food additives permitted in Appendix A. The product shall conform to the microbiological requirements given in Appendix B. It shall meet the following requirements:–

i)	The percentage of total sugar (w/w)	Not less than 70.0
ii)	Percentage of reducing Sugar to total sugar	Not less than 25.0

Regulation 5.3.35 Dehydrated Fruits:

1. Dehydrated Fruits means the product, prepared from edible part of suitable variety of sound fruit, free from blemishes, insect or fungal infection, of appropriate maturity, from which, moisture has been removed, under controlled conditions of temperature, humidity and airflow, to the extent that the product is preserved.

2. It may be whole, sliced, quarters, pieces or powdered. The finished product shall have uniform colour and shall be free from extraneous matter. The product shall have moisture content not more than 20 percent m/m. When in powder form, it shall be free flowing and free from agglomerates

3. The product may contain food additives permitted in Appendix A. The product shall conform to the microbiological requirements given in Appendix B.

Regulation 5.3.36 Dehydrated Vegetables:

1. Dehydrated Vegetables means the product, prepared from edible portions of suitable variety of sound vegetable, free from insect or fungal infection, free from blemishes, suitably prepared, from which moisture has been removed under controlled conditions of temperature, humidity & airflow, to the extent that the product is preserved.

2. It may be whole, sliced, quarters, pieces, flakes, kibbled granules or powdered. The finished product shall have uniform colour and shall be free from discolouration due to scorching or enzymatic reaction. It shall be free from stalks, peels, stems and extraneous matter. When in powder form, it shall be free flowing and free from agglomerates.

3. The product may contain food additives permitted in Appendix A. The product shall conform to the microbiological requirements given in Appendix B. It shall meet the requirements as given in the Table below

S.No.	Name of vegetables	Moisture not more than (%)	Sulphur dioxide not more than (ppm)	Total ash not more than (%)	Ash insoluble dilute HCL not more than (%)	Peroxidase Test
1.	Green leafy vegetables	7	2000 ppm	-	-	Negative
2.	a) Tubers like arvi b) Lotus-roots tapioca c) Yam d) Carrot e) Potato	7	2000 ppm	-	-	Negative
3.	Karela	6	-	-	-	Negative
4.	Cabbage	6	2000 ppm	-	-	Negative
5.	Okra	8	2000 ppm	-	-	Negative
6.	Other vegetables	8	2000 ppm	5	0.5	Negative
7.	Powders of onion & garlic	5	-	5	0.5	Negative
8.	Powders of other vegetables including tomatoes	5	2000 ppm	5	0.5	Negative

ADDITIVES AND PRESERVATIVES

CODEX ALIMENTARIUS STANDARDS

Food Categories No. 04.2.2.2 Dried vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds

S.No.	Name of the Additive	Functional Class	Max Level
1.	Ascorbyl Esters	Antioxidant	80 mg/kg
2.	Aspartame Flavor enhancer	Sweetener	1000 mg/kg
3.	Benzoates (Benzoic acid, Sodium benzoate, Potassium benzoate, Calcium benzoate)	Preservative	1000 mg/kg
4.	ButylatedHydroxyanisole	Antioxidant	200 mg/kg
5.	ButylatedHydroxytoluene	Antioxidant	200 mg/kg
6.	Canthaxanthin	Colour	10 mg/kg
7.	Caramel III - Ammonia Caramel	Colour	50000 mg/kg
8.	Carotenes, Beta-, Vegetable	Colour	200 mg/kg
9.	Carotenoids	Colour	1000 mg/kg
10.	Diacetyltartaric And Fatty Acid Esters of Glycerol	Emulsifier, Sequestrant, Stabilizer	10000 mg/kg
11.	Ethylene Diamine Tetra Acetates	Antioxidant, Colour retention agent, Preservative, Sequestrant	800 mg/kg
12.	Neotame	Flavour enhancer, Sweetener	33 mg/kg
13.	Phosphates	Acidity regulator	5000 mg/kg
14.	Propyl Gallate	Antioxidant	50 mg/kg
15.	Saccharins	Sweetener	500 mg/kg
16.	Sorbitan Esters of Fatty Acids	Emulsifier, Stabilizer	5000 mg/kg
17.	StearoylLactylates	Emulsifier, Flour treatment agent, Foaming agent, Stabilizer	5000 mg/kg
18.	Steviol Glycosides	Sweetener	40 mg/kg
19.	Sucralose (Trichlorogalactosucrose)	Flavour enhancer, Sweetener	580 mg/kg
20.	Sulfites	Antioxidant, Bleaching agent, Flour treatment agent,Preservative	500 mg/kg
21.	Tocopherols	Antioxidant	200 mg/kg

FSSAI STANDARDS

S.No.	Name of the Additive	Standard
Anticaking Agents (Singly or in Combinations)		
1.	Carbonates of calcium and magnesium	2% maximum in powders only
2.	Phosphates of calcium and magnesium	
3.	Silicates of calcium, magnesium, aluminum or sodium or silicon dioxide	
Preservatives (Singly or in combination)		
1.	Sulphur di-oxide	2000 ppm maximum

Sulphites and sulphur dioxide. Sulphur dioxide gas and sodium or potassium sulphite, bisulphite or metabisulphite are the most common forms used. Commonly used levels : 0.005-0.2%
Comments: Fruit puree can be preserved by adding 600ppm sulphur dioxide (SO_2) and sealing in drums. The semi-processed fruit can be stored for several months. Most of the SO_2 that is absorbed during storage is lost during drying, but it is recommended that the puree is boiled before drying to reduce the levels of residual SO_2.

Sorbic acid. Sorbic acid and sodium and potassium sorbate are used to inhibit the growth of moulds and yeasts. The activity of sorbic acid increases as the pH decreases. Sorbic acid and its salts are tasteless and odourless when used at levels below 0.3%. Commonly used levels: 0.05-0.2%

Benzoic acid. Benzoic acid, in the form of sodium benzoate, is a widely used food preservative suitable for acid foods. Benzoic acid is often used in combination with sorbic acid at levels of 0.05 to 0.1%. Commonly used levels: 0.03-0.2%

Citric acid. Citric acid is found naturally in citrus fruit. It is widely used in carbonated drinks and as an acidifier of foods. It is less effective at controlling the growth of yeasts and mould than the other acids.
Commonly used levels: no limit

Permitted levels: The use of chemical preservatives is regulated by maximum permitted levels. These amounts vary between countries. Processors should check with their local authorities for the local regulations and for the regulations in the country of sale. Chemical preservatives cannot be used to cover up for poor quality raw materials. They are only added as a precaution to extend the shelf life of products by inhibiting microbial spoilage. Some chemical preservatives can taint the flavour of fruit juices if the recommended level is exceeded. Some consumers prefer to consume fruit juices with no chemical additives. They may be prepared to pay a premium for these products.

MACHINERIES REQUIRED

The list of various types of driers and its technical details are as given below:

S. No	Machine description	Technical specification	Approx. Cost Rs in Lakhs
1.	Solar tunnel drier (fixed type) 1080 sq.ft.	1" dia. Galvanized pipe structure with one end having (5x2) opening door with complete covered UV (Clear) resistant 200 micron Polyethylene sheet with proper tension made of GI profile fitted with Plastic coated zig-zag steel spring 2mm thick with self tap screws. Self rotated domed head ventilators (4 nos). SIZE : 90 ft X 12 ft X 6 ft., (QNTY. 2 No.) capacity 500 kg/ batch per drier	8.00
2.	Polycarbonate Solar Tunnel Dryer (fixed type) 720 sq. ft.	1" & 1.5" Sq Galvanized pipe structure with one end having (5'x5') opening door with complete covered UV resistant (CLEAR) Polycarbonate sheet 6mm thick with proper tension made of Aluminium flats fitted leak proof lining. Complete structure water proofed. Self rotated domed head ventilators (3 nos). SIZE : 60 ft X 12 ft X 6 ft.	12.00
3.	Solar drier (Hybrid)	Capacity: 40-60kg/batch wet wt., Operating temp.:45^0C -60^0C, Heating: solar with electrical backup, power supply:415V, 3phase, 50HZ with earthing (connected load 12 Kw), Construction complete SS, control panel digital control with automatic temperature controlling and switch over to back up	13.0
3.	Tray drier	196 trays, product holding capacity 400 to 500kg, with trolleys -2 Nos,	20.00
4.	Fluid bed dryer	Capacity 60kg, Gross volume approx.. 110ltr., operating temp. 60-70^0C, Heating element Electric, Power supply 415V, 3 phase, 50HZ with earthing.,	15.00

		Made SS 304, digital control panel for electric and pneumatic operations.	
5.	Radio frequency dryer	11 kw capacity, 40 Mhz frequency	15.00

The list of other equipment required for dehydration of fruits and vegetables are as given below:

S. No	**Machine description**	**Approx. Cost Rs in Lakhs**
1.	Chaffing machine	6.00
2.	Separator	7.50
3.	Bubble tub washer (2 sets)	12.00
4.	High pressure steam boiler 2 tons / hr	10.00
5.	Steam blancher 250 kg/hr (2 sets)	15.00
6.	Spin dryer (2 sets)	10.00
8.	Impact/hammer mill (2 sets)	20.00
9.	Single line pulverizer 300 to 400kg capacity	8.00
10.	Vibro screen	5.00
11.	Ribbon blender 300 to 400kg capacity	5.00
12.	Storage silos (4 nos.)	5.00
13.	Metal detectors (2 sets)	12.00
14.	Weighing, filling, sealing - retail and bulk pack (2 sets)	30.00
15.	Tablet press (forming, filling, sealing)	22.00
16.	Weighing machine - accuracy 1 ton, 100 kg, 1g to 5kg	0.75
17.	Accessories: racks, storage bins, working table, trolleys, trays and containers	15.00

The chaffing machine will be costing around Rs.6 lakh and for separator is Rs.7.5 lakh. The washing systems will be costing around Rs.12 lakh for 2 sets. The steam boiler requirement will be around 2 tons/hr capacity, which will cost around Rs.60 lakh including piping, insulation, cladding, instrumentation, chimney, feed water tank etc. Spin dryers will be costing around Rs.10 lakh for 2 sets. These dryer is multi deck conveyor dryer with steam used as hot air source. The dryer output capacity will be around 125 to 150 kgs of dried leaves. The impact / hammer mill with rotary air lock, cyclone and dust collection bag filter of 2 sets, one for coarse milling and another one for fine milling, both of 150

kgs/hr capacity will be required. The stainless steel model of the mill and its accessories will be costing around Rs.18 to 20 lakh. The Ribbon blender will be costing around Rs.4 lakh. You need storage silos 4 nos of 500 kgs each cost will be around Rs.5 lakh. Metal detectors are required 2 sets with the cost of Rs.12 lakh. Bulk and retail packing system is included. Tablet forming, filling and sealing equipment is added as optional. The detail of the various types of dryer is given in the following Table 3.

MACHINERIES MANUFACTURERS AND SUPPLIERS

S.No	Name of the Manufacturers	Name of the Machineries
1.	**M/s Industrial Fabricators** 2321, Lane Adj.BoB, GIDC, 3rd Phase Vapi., Gujarat 396196. Mobile:+91 9998540492 response@dryersindia.com	Tray dryers, fluid bed dryers, industrial ovens, continuous dryrs, SS/MS vessels and heavy duty strucutrues
2.	**M/s Accelor Food Tech Pvt Ltd** 22, RVL Nagar, Uppilipalayam Post, Coimbatore - 641 015, Tamilnadu, India. Mobile: 9994411095	Blancer with washer, tray dryer, boiler, multi stage pulversier, ribbon blender, double deck tunnel dryer, filling machine
3.	**M/s Pilotsmith (India) Pvt. Ltd.,** Kallettumkara P.O., Thrissur - 680 683 Tel.No.:+91- 4802881157	Drying and dehydration process plant
4.	**M/s ALFAGREEN** Coimbatore Tel.No.: 0422 2929447 Mobile: 094434 68527 Website **:** www.alfagreen.in	Solar Tunnel Dryer
5.	**M/s Sun Best Solar** Address: 238/10 Nehruji Road, Valli Nagar Theni Allinagaram-625 531 Tel.No.: 04546 255 374	Solar dryers
6.	**M/s Energy Microwave Systems Pvt.Ltd.,** # 48/D-156/2, H.M.Udyamnagar, 4th, 'N' Block, 3rd Stage, Rajaji Nagar Bangalore-560 010	Continuous drying system
7.	**M/s Industrial Laboratory** PB.No:6063, No:38, 1st Floor, 2nd Street Anjugam, 5 No. Gam JaferKabent Chennai Mobile : +91- 9840836548	Tray Drier
8.	**M/s Lakshmi Card Clothing Manufacturing Company Pvt.Ltd** Coimbatore- 641 037 Tel.No.: 0422-2240205 Mobile: 98432-77350 Email: karuna@lakshmicardclothing.com Website: www.lakshmicardclothing.com	Radio Frequency Dryer
9.	**M/s Sri Bramha Industries** ERS complex, Opposite to SIT Trichy-Thanjavur	Steam Blancher, Boiler, SS double jacketed kettles, racks, storage bins,

	road, AriyamangalamTrichy- 620010 Mobile: 9842471388, 9842471326, 9865699922 Email:bramhaindustries@gmail.com, ramhabhoy@gmail.com	working table and utensils
10.	**M/s Fowler Westrup India (Pvt) Ltd.** Plot 249/250, Bommasandra Indl. Estate, 3rd Phase Bangalore - 562 158 Tel.No. : 080-7832991, Fax : 080-7832990	Cleaning/grading plant
11.	**M/s Bansal Flour Mill Engineers** A/8, RajasthaniUdyog Nagar New Delhi-110 002, India. Tel.No. : 011-27426944, Fax : 011-27224819	Flour mill machinery, roller mills, plansifier, purifier, cleaning, sorting, pneumatic conveyors, erection, cleaning
12.	**M/s Ankon Engineering** 518/B, Devarachikkanahalli Road, Bilekahalli Bannerghatta Road, Bengaluru - 560076	Ribbon blender
13.	**M/s Ramtech Refrigeration Private Limited** 5 & 6, Sathish Nagar, ThirumudivakkamKanniammanKoil Street, Chennai – 600 044, Mobile : 08071804548	Blancher with washer, conveyors
14.	**M/s Pearl Packaging** 652/1,Sri CV Raman Industrial Estate, Near Rathinam College Eachanari (PO), Coimbatore – 641 021 Tel. No.:0422 6529795 Mobile: +91-9994917322, 9443378322	Form fill sealing and packing unit
15.	**M/s Durapak** Old No.4, New No. 12, Norton First Street, Mandaivellipakkam, 1st St, Krishnapuri, Raja AnnamalaiPuram, Chennai - 600 028 Tel.No.: +91 - 44 4303 3533	Band sealing machine
16.	**M/s ATMA TECHNOLOGIES** NewNo.97,SouthSivanKoilStreet, LandMark(BehindKamalaCinema), NearK.M.GKalyanaMandapam Vadapalani, Chennai – 600 026. Tel.No.: +91-44-2372 8922 Mobile : +91-98401 13136 / +91-90030 26293 Fax : +91-44-2480 6230	Weighing machines

RECOMMENDED STORAGE CONDITIONS FOR VEGETABLES BEFORE DRYING

Commodity	Storage Temperature* (°F)	Relative Humidity (%)	Average Storage Life
Asparagus	32-36	95-100	2-3 weeks
Bean & pea, dry	32-40	65-70	1 year
Bean, green or snap	40-45	90-95	7-10 days
Bean, lima	37-41	90-95	5-7 days
Beet (topped)	32	90-95	3-5 months
Cabbage	32	90-95	1-2 months
Carrot	32	90-95	4-5 months
Cauliflower	32	90-95	2-4 weeks
Celery	32	90-95	2-3 months
Corn, sweet	32	90-95	4-8 days
Cucumber	50-55	90-95	10-14 days
Brinjal	45-55	90-95	1 week
Garlic, dry	32	65-70	6-7 months
Lettuce	32	95	2-3 weeks
Melon, muskmelon	32-40	85-90	5-14 days
Melon, watermelon	40-50	80-85	2-3 weeks
Mushroom	32	90	3-4 days
Okra	45-50	90-95	7-10 days
Onion, dry	32	65-70	1-8 months
Onion, green	32	90-95	3-5 days
Pea, green	32	90-95	1-3 weeks
Pepper, dry	32-50	60-70	6 months
Pepper, sweet	45-50	90-95	2-3 weeks
Potato	40-45	90	2-9 months
Pumpkin	50-55	70-75	2-3 months
Radish	32	90-95	3-4 weeks
Spinach	32	90-95	10-14 days
Sweet Potato	55	85-90	4-6 months
Tomato, mature green	55-70	85-90	1-6 weeks
Tomato, colored, firm	46-50	85-90	4-10 days
Turnip	32	90-95	1-6 weeks

NAMES OF FRUITS AND VEGETABLES IN DIFFERENT LANGUAGE

Name of the Fruit						
English	**Scientific**	**Tamil**	**Hindi**	**Telugu**	**Malayalam**	**Kanada**
Almond	*Amygdalus communis*	Badam	Badam	Badam	Badam	Badam
Custard Apple	*Annona reticulata*	Seethaa pazham	Ramful	Sita phalam	Aattha chakka	Sithaphala
Aonla	*Phyllanthus emblica*	Nellikkai	Amla	Usiri	Nellikka	Bettanalli
Apple	*Malus pumila*	Apple	Sev	Aapilu	Apple	Apple
Avocado	*Persea americana*	Vennai Pazham	Makhanpha	Nyaayavaade	Goshtubtang	Benne hannu
Bael	*Aegle marmelos*	Vilva pazham	Siriphal	Maredu	Koovalam	Bilva
Banana	*Musa Sp.*	Valaipazlam	Kela	Aratikaya	Valaipazlam	Bale hannu
Ber	*Ziziphus mauritiana*	Ber	Ber	Ber	Ber	Ber
Apricot	*Prunus armeniaca*	-	Khoobani	-	-	Jardalu
Fig	*Ficus carica*	-	Anjeer	-	Figs	Anjura
Grape	*Vitis vinifera*	Therachai	Angoor	Dhraksha pallu	Munthiringa	Dhrakshi
Guava	*Psidium guajava*	Koiya	Amuth	Jaama	Perakkai	Seebe kayi
Jack Fruit	*Artocarpus heterophyllus*	Palappazham	Kathal	Panasa	Chakka	Halasu
Lime and Lemons	*Citrus aurantifolia*	Yealumichaipalzham	Nimbu	Nimma pandu	-	Nimbe
Mango	*Mangifera indica*	Mamplazam	Aam	Mamidi pandu	Manga	Mavina hannu
Papaya	*Carica papaya*	Pappali	Papita		Pappaya	
Pineapple	*Ananas comosus*	Annachipalzha	Ananas	Anaasa pandu	Kaithachakka	Ananas
Plum	*Prunus salicina*	Plum	Aloobukara	-	-	-
Pomegranate	*Punica granatum*	Madhulampalzham	Anaar	-	Pommegranate	-

Sapota	*Manilkara achras*	Sapota	Chikuaonla	-	Sappotta	-
Sweet Orange	-	Nagarugam	Narangi	Naringa	Orange	-

Name of the Vegetables						
English	**Scientific**	**Tamil**	**Hindi**	**Telugu**	**Malayalam**	**Kanada**
Agathi	*Sesbania grandiflora*	Agathi	Agathi	Agathi	Agathi	Agathi
Amaranth	*Amaranthus spp.*	Amaranth	Chauli	Thotakura	Amaranth	Callaloo
Ash Gourd	*Benincasa hispida*	-	Petha	-	-	Budagumbala
Beet root	*Beta vulgaris*	Beet root	Chukander	Beet root	Beet root	-
Bitter Gourd	*Momordica charantia*	Pavatkai	Karela	Kakarkaya	Pavakka	Hagalkai
Bottle Gourd	*Lagenaria siceraria*	Pudalangai	Loki (Lauki)	Anapakaya	-	Soreikai
Brinjal	*Solarium melonena*	Katherikkai	Baingan	Vankaya	Vazhuthinanga	Badhanekayi
Broccoli	*Brassica oleracea var. italica*	Karai	Hari Phool Gobhi	-	-	-
Brussels Sprout	*Brassica Oleracea var.gemmifera*	-	Chhoti Gobhi	-	-	-
Cabbage	*Brassica oleracea var. capitata*	Muttaikos	Pattagobhi	Gobi	Cabbage	Kosugaddae
Cauliflower	*Brassica oleracea var.botrylis*	Cauliflower	Phoolgobhi	Gobi puvvu	Cauliflower	Hookosu
Chilli	*Capsicum annuum*	melagai	Mirch	-	-	menasina kaayi
Curry Leaf	*Murraya koenigii*	karuveppillai	-	karuveppillai	-	karbevina soppu
Drumstick	*Moring Oleifera*	Muringakka	-	-	Muringakka	nugge kaayi
French Bean	*Phaseolus vulgaris*	-	Flash (Frash)	-	-	Hurulikey

			Beans			
Lettuce	*Lactuca sativa*	-	Kasmisaag	-	-	-
Onion	*Allium cedpa*	vengayam	Pyaz	Ullipayalu	Ulli	eerulli
Spinach	*Beta vulgaris*	Keerai	Palak		Spinach	
Pea	-	pattani	Matar	Bataneelu	Green peas	Battani
Pumpkin	*Cucurbita moschata*	Kumbalanga	Kaddu	-	Kumbalanga	Kumbola
Radish	*Raphanus sativus*	Mullanki	Mooli	Mullanki	Mullanki	Moolangi
Ridge guard	*Luffa acutangula*	-	Tori	Beerakaya	-	Heeraikai
Snake Guard	*Trichosanthes cucumerina*	Snake gourd	Chichonda	potlakaya	Snake gourd	Padavala
Tomato	*Lycopersicon esculentum*	Thakkali	Tamater	Rama Mulaga	Thakkali	Tomaato
Turnip	*Brassica rapa*	Turnip	Shalgam		Turnip	-
Potato	*Solanum tuberosum*	Urulakizhangu	Alu	alu gadda	Urulakizhangu	Alugedde
Yams	*Dioscorea species*	Seanaikelangu	-	-	-	-
Sweet Potato	*Lpomoea batatas*	SakkaravalliKelangu	Shakarkand	-	Madhurakkizhangu	-
Ladies Finger	-	Vendakkai	-	-	Vendakkai	bende kaayi

GOOD MANUFACTURING PRACTICE (GMP)

They are a series of general principles that must be observed during manufacturing. When a company is setting up its quality program and manufacturing process, there may be many ways it can fulfill GMP requirements. It is a production and testing practice that helps to ensure a quality product.

GMP Checklist

Employees and trainees	Equipment	Buildings and facilities	Production and process control
❑ Well trained in what they do ❑ Hair covering / net ❑ Beard covering ❑ Disposable gloves ❑ Clean uniforms or coats ❑ No injuries / illness ❑ Clean cut nails ❑ No Jewellery / phones / watches ❑ Wash hands ❑ Clean personal habits ❑ Documented classes and trainings	❑ Follow appropriate cleaning schedule for each equipment ❑ Should be designed for food plants and not contain polychlorinated biphenyls (PCBs) ❑ No build up of food or other material ❑ No build up of cleaning solvents / detergents ❑ Should be easy to disassemble for clean up and inspection ❑ No dead space in the machinery to prevent growth of microbes ❑ Sanitization of equipment surface	❑ Area around - Clear of litter, weeds, grass, bush ❑ No standing water around ❑ Clean maintenance of floors, walls, ceilings, windows, screens and no flaking paints ❑ Insect prevention by mesh screens ❑ Tightly sealed windows and doors ❑ Absence of cracks and holes ❑ No evidence of domestic animals ❑ Clean rest rooms ❑ Refilling of hand washing facilities – soaps, paper ❑ No leaks in the premise – roof, walls, windows ❑ Overhead lights covered with shield	❑ Products stored in first in, first out basis ❑ Internal products dated ❑ No overstocking – causes spoilage ❑ Inspection of incoming vehicles ❑ Regular checking of faded, dusty, discolored containers ❑ Spoiled foods to be placed separately in Quarantine area ❑ Disposal of quarantined items quickly ❑ Inspection of incoming materials for damage or contamination ❑ Proper sealing of unused materials ❑ Storage of materials in safe manner ❑ Setting up of effective procedure recall