DEHYDRATION OF FRUITS & VEGETABLES

Subject: Food technology

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Drying is one of the oldest and most widely used methods of food preservation. The removal of water from food products before marketing may be referred to as dehydration, drying or evaporation. The term evaporation is used when the resultant product is still liquid or fluid stage.

This episode deals with
1.Solar drying
2.Dehydration
3.Drying Methods
4.Pretreatment's
5.Drying of apples

Basically fruits and vegetables are dehydrated either by
- i) Sun drying also called natural process of drying and
- ii) Dehydration called artificial drying

In the recent years much of the attention is focused on the use of solar dehydration in order to conserve energy source. Although considerable quantities of fruits like grapes and vegetables like cauliflower, cabbage, okra, bitter gourd, carrot, turnip etc. are dried in the sun the quality of the product is rather poor

1.0 Solar Drying

There are two main types of drying using solar energy: Direct and Indirect. In direct solar drying commonly called open sun drying the product is placed directly on trays in open air where incident solar radiation is used as the energy source for drying.(**1**)

1.1 Sun drying of vegetables: In sun drying, vegetables are not given any blanching treatment which is necessary to destroy enzymes that cause discoloration. Enzymes such as peroxidase and catalase are responsible for the browning of the product. It has been shown that even blanched vegetables when dried in sun were found unsatisfactory at the end of one year storage period. They were poor in quality and had a poor dehydration ratio.

1.2 Sun drying of fruits: In sun drying fruits are subjected to sulfuring treatment to prevent enzymatic and non-enzymatic browning of the product.

The treated fruits are spread on a slotted wooden trays 90cm× 60cm with sides about 5cm high and with flat bottom are convenient for handling the fruits. The trays are exposed to direct sunlight for about 5 days and then turned over to expose the bottom layer to the sun for another 5 days. The trays are then stocked in the shed to complete drying. It usually takes about 20-25days for satisfactory drying. Grapes are usually dried as bunches.

The dried fruits are placed in air tight wooden boxes or rooms for about a month to undergo sweating or equilibration of moisture. The over dried fruits absorb moisture from the fruits of higher moisture content, and the surface of the fruits becomes moist through the diffusion of moisture from the interior of the fruit to the surface. During the treatment a fumigant such as methyl bromide may be used at 1 pound per 1000 cubic feet to destroy any insect that may have harbored during sun drying step. The boxes after 24hrs.of the treatment are continued to be dried as before.

Although direct sun shine is simple economical and requires minimal labour, the product directly sun dried are highly susceptible to insect infestation, requires large area, inability to control degradation of product by biochemical or microbial reactions etc. Under these circumstances solar drying technology is considered very practical for rural communities because of the following advantages.

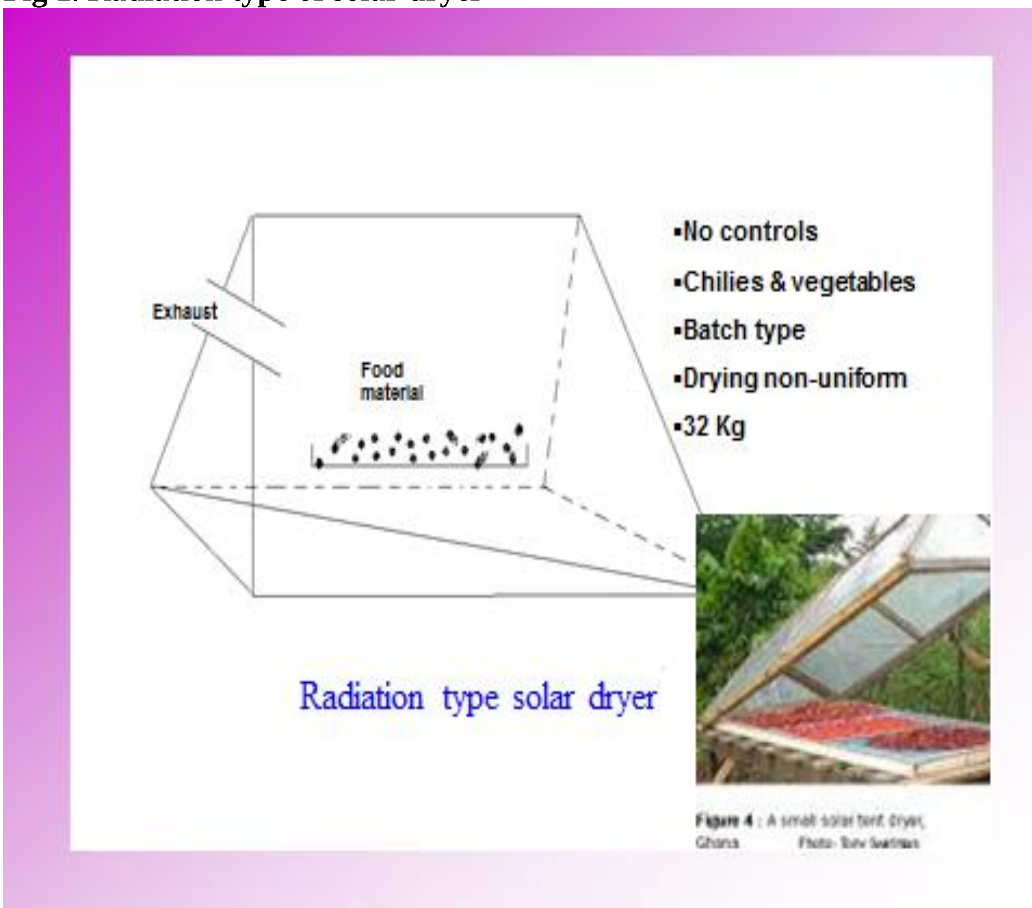
Advantages of solar drying

- i) Low investment
- ii) Labour cost saving
- iii) Low delivery cost
- iv) Product free from insect and mold contamination
- v) Longer shelf life and better organoleptic quality

1.3 Radiation type: Radiation type solar cabinet dryers are suitable for drying chilies and vegetable etc. have been developed by large number of institutes. The product to be dried is spread thinly in the trays and exposed to direct radiation from the sun. There are no controls beyond the adjustment of the orientation of cabinet and the drying of the product is non-uniform. This type of drier is found to be suitable for drying only small batches of material.

A polyethylene tent drier developed by **Doe etal.(2**) operates by absorbing solar radiation through the clear polyethylene onto the back surface of the dryer, thus increasing the temperature of the air inside the drier. Moisture removed from the food during drying is generally carried out of the drier with the exhaust air or condenses inside of the polyethylene sheeting. The estimated capacity of the drier is about 32Kg. for fruit.(Fig 1).

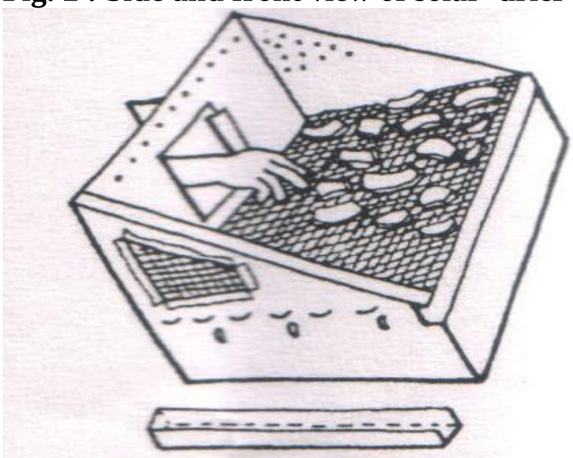
Fig 1. Radiation type of solar dryer



The drying time of the fruits in polyethylene tent drier and ordinary sun drying to obtain the optimum moisture content of the product. The time required to dry fruits in polyethylene tent dryer is much lower (16-18 hrs.) compared to direct sun light (24 hrs.) to get the product of moisture content ranging from 12 to 12.6.

The indirect solar dryers use solar energy to heat the drying air in special heat exchangers (solar collectors) and then this air flows through or over the product by natural or forced convection. Fig 2 shows one of the most common and simple solar dryer for vegetables and fruits- the cabinet dryer **(3**). It is composed of solar collector followed by a packed bed dryer. The air conditions at the inlet of the (air humidity and temperature)vary with time.The main advantage of these dryers is that the energy source is renewable, free and nonpolluting**(4)**on the other hand this type of drying is only useful in climates with hot sun and dry atmosphere **(5).** Fruits commonly dried using solar energy include, fig, apricot, peaches and to large extent grapes

Fig. 2 : Side and front view of solar drier



2.0 Dehydration

The use of heat from fire to dry foods was discovered by many workers in the new and the old world. Ancient men dried foods in his shelters, American Indians used heat from fire to dry foods. However, it was not until 1795 that a hot air dehydration room was invented. The team of Mason and Chalet**(6)** in France developed a vegetable dehydrator consisted of hot air (40°C) flow over thin slices of vegetables.

2.1 Why dehydration

Dehydration of fruits and vegetables offers some advantages. They are

1. Reduction in bulk for storage, transportation and packaging.
2. Convenience in use
3. Better storage stability because of the reduction in water activity thereby preventing microbial growth.
4. Dried and dehydrated foods are concentrated foods as calorific value is too high.
5. Can be used in the event of wars, famine, exploration, space travel and outbreak of diseases and floods etc.

3.0 Dehydration Methods: The best drying method for the food product is determined by quality requirement, raw material characteristics and economic factors.

3.1 Cabinet, tray and pan driers: The cabinet dryers may be classified as an air-convection batch tray drier, intended for relatively small scale operation. Air flow may be across or through the trays with or without recirculation. It has a capacity to dry the product during the season in quantities ranging from 1 to 20 tons per day. The cabinet dryers are least expensive dryers to

Fig 3. Cabinet dryer

build and easy to maintain. It is commonly used for laboratory studies in the dehydration of fruits and vegetables.

3.2 Tunnel driers: A tunnel drier is basically a group of truck and tray dryers. These are most commonly used for dehydration of fruits and vegetables. They consist of tunnels 10-20 meter long into which trucks containing the trays of the food are placed. Hot air is blown across the trays. Production is scheduled so that when the truck of the finished product is removed from one end of the tunnel, a truck of the fresh product is put to the other end.

Air movement may be in the same direction as the movement of the product. This is referred to as parallel flow. This has the advantage that the hottest air contacts the wettest product. Therefore, hotter air can be used.

The air movement may be in the opposite direction of the material flow. This is referred to as counter-current flow. In this case the hot dry air contacts the driest product first so that very dry end product can be obtained.

In some cases, the two types of tunnels are combined into one unit. The product is first placed in the parallel tunnel to take advantage of high initial rate of drying. It can then be placed in a counter current tunnel to get very dry end product.

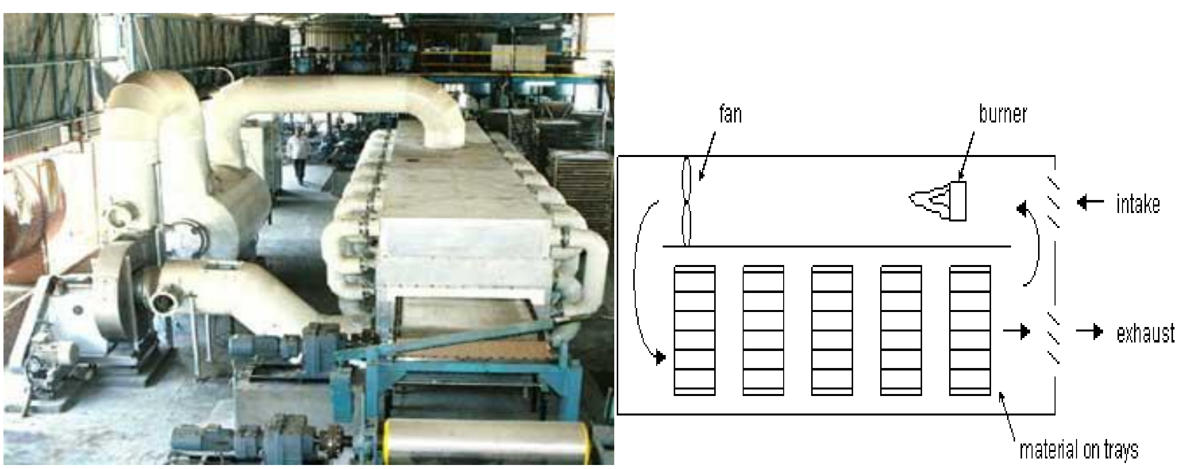
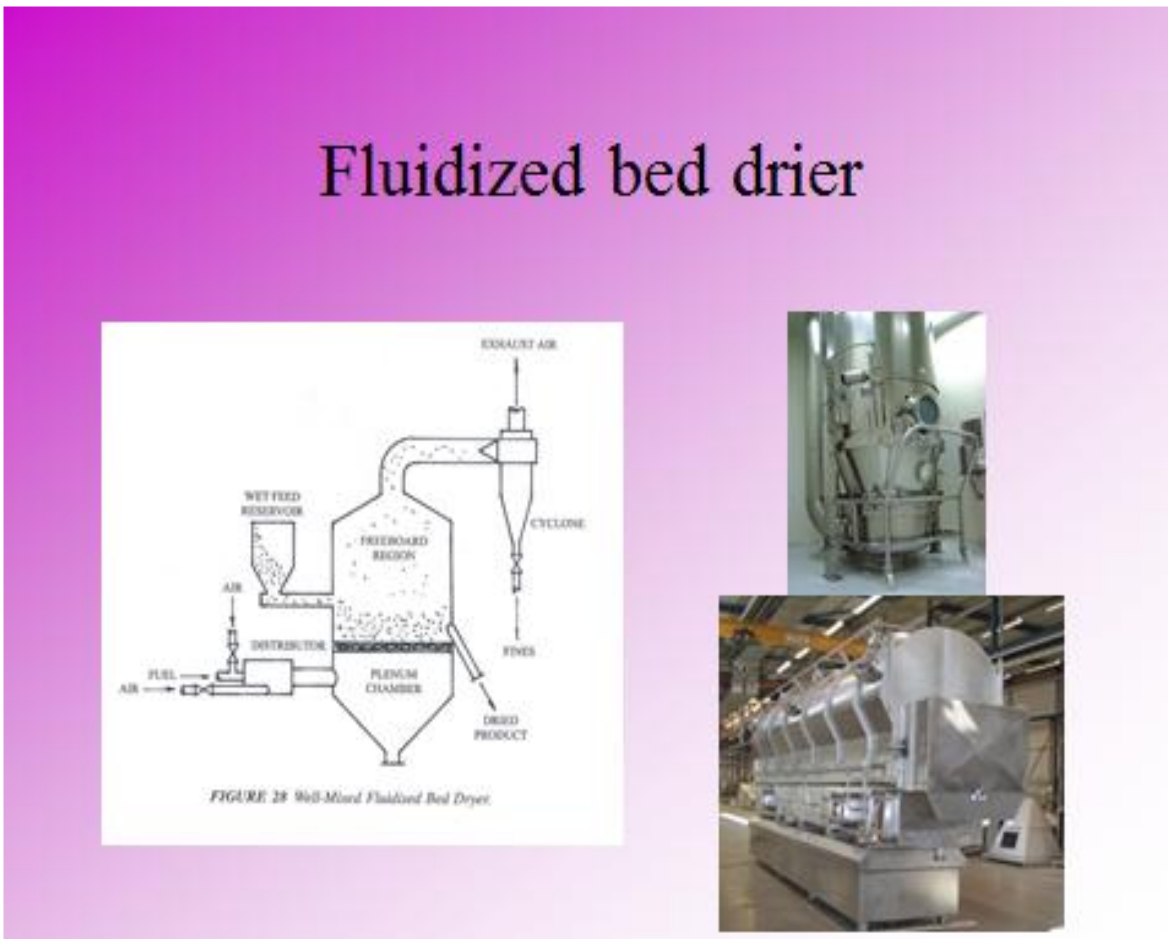


Fig 4 . Tunnel dryer

3.3 Continuous conveyor drying: The dryer consists of an endless belt that carries the material to be dried through tunnel of warm circulating air. Best suited for large scale drying of a single commodity for the whole operating season.It is not well suited for operations in which the raw material or the drying conditions are changed frequently. It has the advantage of essentially an automatic operation, which minimizes labour requirement. Suitable for onion, carrot, beet, potato and sweet potato pieces.

3.4 Fluidized Bed drying: In this drier, the heated air is blown up through the food particles with just enough force to suspend the particles in a gentle boiling motion and to convey it towards the outlet. Semidry particles such as potato granules enter the left and gradually migrate to the right where they are discharged dry. Heated air is introduced through the porous plate that support the bed of granules . The moist air is exhausted at the top. This is a continuous operation and used mainly to dry grains, peas and other particulates.(Fig 5)



3.5. **Vacuum shelf drier:** This consists of a cabinet with hollow shelves. The product is placed in a pan on the shelves or if solid, it can be laid directly on the shelves. The unit is closed and a vacuum drawn, steam or hot water is circulated through the hollow shelves, heating the product. These units are expensive.

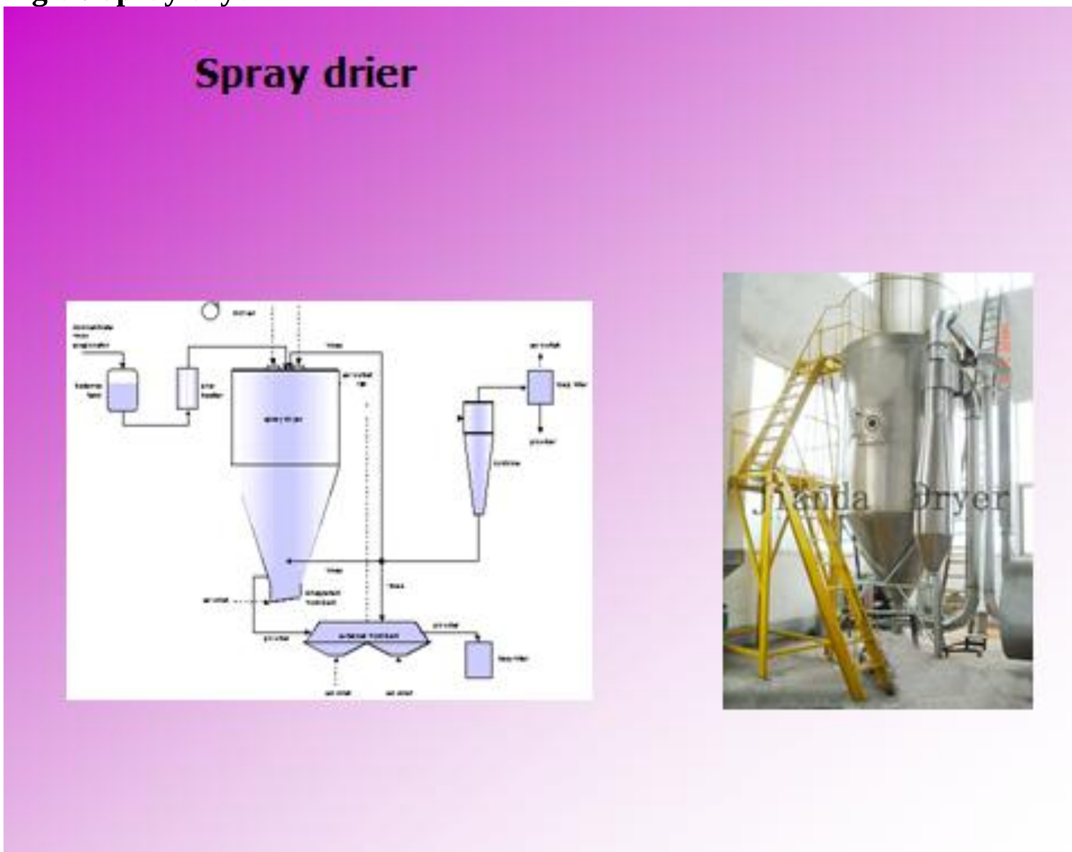
3.6. **Freeze drying:** In this method, the material is first frozen on the trays in the lower chamber of the freeze drier and the frozen material is dried in the upper chamber under high vacuum. The material dries directly by sublimation of ice without passing through the intermediate liquid stage. The main advantages of this drying method are related to high quality of final product compared with other drying methods.The advantages are (1) High retention of flavor and aroma (2) High retention of nutritional value (3) minimal shrinkage (4) Minimal changes in shape,colour and value (5) Practically no damage in structure and texture (6) Porous final structure (7) Easilyrehydatable. (7,8)

The industrial application of freeze drying to a wide range of fruits has been limited by its main disadvantages: the high capital and operating costs. In addition, the final product has to be packed in a special material to avoid oxidation and moisture pick up.

3.7 **Spray drying :**By far the most important kind of air convection dryer is the spray dryer. Spray dryers are limited to foods that can be atomized such as liquids and low viscosity pastes and purees. Atomization into minute droplets results in drying in a matter of few seconds with a common inlet temperature of about 200 °C. Since evaporative cooling seldom permits particles to get warmer than about 80°C and properly designed systems quickly remove the dried particles from the heated zones. This method of drying can produce exceptionally high quality product with highly heat sensitive materials.

In a typical spray drying equipment, the liquid food is introduced as fine spray or mist into the chamber along with the heated air. As the droplets make intimate contact with the heated air, they flash off their moisture , become small particles , and drop to the bottom of the chamber from where they are removed.The process is continuous.(Fig 6)

Fig 6 : Spray dryer



3.8 **Microwave drying** : Conventional drying of foods is a slow process. Attempts to enhance this process have been made but only few of them are presently applied in the industry. Microwave heating increases the temperature of the interior, wetter part of the solid. In addition moisture transport to the evaporation surface is also enhanced by an internal pressure gradient.

Microwave heating has three main advantages. (9) 1. A penetrating quality that leads to the uniform drying (conventional drying may cause damage to the surface of the product.2. selective adsorption by liquid water which leads to uniform moisture profile within the particle. 3 ease of control due to the rapid response of such heating. Advantages 1 and 2 increase the quality of the product and make it easier to be rehydrated. Apple, mango and pineapple were investigated for the drying under vacuum (10).

3.9 Osmotic dehydration : Hot air drying notably reduces the quality of the processed foodstuff (changes in colour, shape, loss of aroma and nutrients etc.). Osmotic dehydration is an alternative technology to reduce the water content , as well as to improve the quality of the final product. Osmotic dehydration involves the immersion of cut fruits or vegetables in a concentrated solution of sugar in case of fruits and in salt for vegetables. A flux of water out of the food and other solute into the food stuffs develops due to the difference in osmotic pressure, thereby nearly 50 % reduction in the weight of the product can be achieved (11).
A typical flow sheet forosmotic dehydration of fruits is shown **(Fig**7). Mango, banana, pear, apple, guava, pineapple,amla(*Indian gooseberry*) etc. have been dried using this technique.

Fruits (Cut or whole)

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Pre treatment

(blanching, SO_2 etc.**)**

↓

Draining

↓

Fruits

↓

Air drying

↓

Storing

Fig 7 : Flow diagram for the osmotic dehydration of fruit

4.0 **Pretreatments**

For better sanitation, storage stability and retention of flavour and nutritive qualities, dehydration of fruits vegetables proceeds with various pre-treatments depending upon the type of vegetable. The various methods available for pre-treatments and their objectives are summarized.

i)**Washing:** To remove adhering dirt, and soil and to reduce microbial load

ii) **Peeling:**for root vegetables like beets, carrot, parsnips, potatoes, sweet potatoes; to remove unedible portion

iii)**Trimming:** To remove eye, specks, unpeeled green and rotten portion.

iv) **Topping and tailing** for snap beans and okra for uniform size and shape of the product

v) **Slicing** for (a) Root crops as cubes or slices

(b) Cabbage: Shredding

(c) Potatoes: dicing

(d) Beans, peas, lima beans - shelling

To obtain uniform size and shape and to enhance cooking and drying.

vi**) Blanching**

(a) To inactive the enzymes (peroxidase and catalase) responsible for discoloration and change in flavour and aroma

(b) To remove intracellular air from the tissues (which makes the product limp and easy to pack

(c) To remove microbial load, to cook partially which causes softer texture

(d) To fix the green colour (chlorophyll)

(e) To achieve better retention of ascorbic acid and carotene.

(f) To remove harsh flavour as in turnip, spinach, okra and snapbeans and

(g) To reduce drying time.

Various methods such as water blanching, steam blanching, hot air, infra-red, microwave, radiation, ionizing can be employed for the blanching operation.

vi) Starch dipping for carrots to prevent leaching of sugars
vii) Sodium chloride treatment for carrot and potato to increase rehydration ratio.
viii) Glycerol treatment for celery and cauliflower to increase rehydration ratio and to improve the texture of the final product.
ix) Sugar solution treatment to increase rehydration ratio and to improve the flavor
x) **Sulphitation** :To prevent scorching and to prevent non-enzymatic browning (on storage). To increase retention ascorbic acid.

5.0 Dehydration of apples

Apples are never sun-dried but dehydrated either by means of tunnel driers or in kiln depending upon the type of the product desired. Vacuum drier are used for preparing dehydrated apples of 3% moisture content.

5.1 Storage of fruits: can be stored for several months at 35 to 38^{o}F, length of the storage depending upon the variety and waxing treatment prior to storage.

5.2 Washing: Washing is carried out to remove grits and dirt. Since the apples are subsequently peeled, it is not necessary to give acid wash to remove spray residue unless the waste is used for feed or other purposes. If the peel is to be dried for pectin manufacture or for feed purposes, and the fruit has been sprayed, it will be necessary to acid treat before peeling. This may be carried out by immersing the apples for about 3 min in a 0.5 to 1.0 percent solution of hydrochloric acid at 70^{0}F.

5.3 Peeling and coring: This is done by machine, peeling and coring being accomplished in one operation. Peeling should be thorough because subsequent grading of the dried product will be governed to some extent by the presence of peel. Peeling, trimming, coring loss will amount to from 25 to 40%.

5.4 Slicing or dicing: The peeled, trimmed fruit may be sliced into rings, ½ inch thick, diced ¼ inch cubes, quartered or sliced.
5.5 Sulphitation: The fruits are then sulphited
5.6 Drying
5.7 Packaging

APPLES

Before drying apples, it is necessary to sort the fruit

Apples

↓

Sorting, peeling and coring

↓

Trimming

↓

Slicing

↓

Sulphuring or sulphiting for

15-30 min.

↓

Drying at 60-71 ^{0}C for 6 to 10 hrs.

For slices, rings or cubes

↓

Packaging

Drying ratio is 10:1

Fig8 : Typical flow sheet for the dehydration of apples

6.0 Terminology used in Dehydration

Drying ratio: $\dfrac{\text{Wt. of the prepared product entering the drier}}{\text{Wt. of the dryproduct leaving the drier}}$

e.g. 10 Kg. of prepared material gives 1 Kg. of dry product then DR will be 10:1

$$\textbf{Overall shrinkage ratio:}\ \frac{\text{Wt. of the fresh unprepared material entering the dehydration plant}}{\text{Wt. of the dry product leaving the drier}}$$

e.g. 12 Kg. of unprepared material give 1Kg. of dry product then OSR will be12:1

$$\textbf{Rehydration ratio:}\ \frac{\text{Wt. of the dry product taken for rehydration}}{\text{Drained wt. of the rehydrated product}}$$

e.g. 1 Kg. of dried material gives 6 Kg. of material on reconstitution then RR will 1:6

The types of driers and the products upon which they are used generally are as follows:

Drier	**Product**
Drum drier	Milk,vegetable juices, cranberries, bananas
Vacuum shelf drier	Limited production of certain foods
Continuous vacuum drier	Fruits and vegetables
Continuous belt drier (atmospheric)	Vegetables
Fluidized-bed drier	Vegetables
Foam-mat driers	Juices
Freeze driers	Fruits and juices
Spray driers	Fruit juices, concentrates
Cabinet or compartment driers	Fruits and vegetables
Kiln driers	Apples, some vegetables
Tunnel driers	Fruits and vegetables

With the ever increasing demand of dehydrated fruits and vegetables in the domestic and international market, there is an urgent need to develop suitable dryers which will have a minimum residual time for the product without affecting its quality.