Solar Drying

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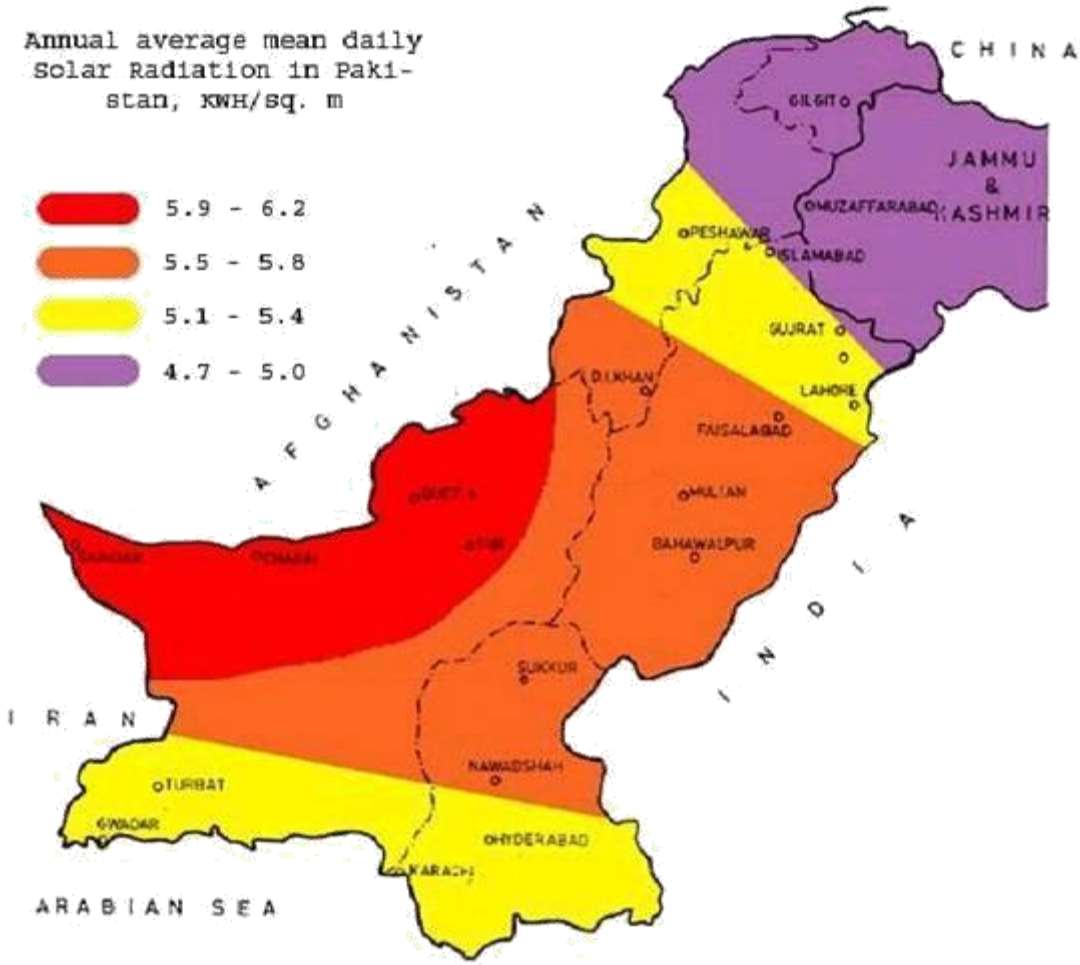
Solar Energy

Among all renewable energy sources, solar radiation is in abundance, freely available, widely distributed and can easily be converted into other forms of energy. This makes solar energy the most promising future source of energy. On reaching the earth its peak value at the sea level is 900 to 1000 W / m^2 global irradiation falling on the horizontal surface is about 1.5 - 2.0 MWh / m^2 per year. This value is more than 10,000 times the current value of all type of energies that the world is using. The mean global irradiance falling on horizontal surface in Pakistan varies from 4.7 -- 6.2 kWh/m^2 the number of clear sunny days in the country varies from 250 in the Northern region to above 300 days in most part of the rest of the country.



SOLAR DRYER

Agriculture forms the base of the Pakistan economy, which produces large quantities of grains, fruits and vegetables. But due to the inadequate post harvest care, it is estimated that about 30-40 percent of the produce is wasted. If solar dryers are used to remove excess moisture from the product before storage, their quality will not deteriorate during storage and insect infestation will be reduced. Similarly, large quantities of excess vegetable and fruits, now being wasted, could be solar dried in a controlled manner for use during off-season.

Basic Principle

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

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

What can be dried?

The solar dryer is suitable for all fruits and vegetables.

How to dry?

Food to be dried is cut in halves or slices or shredded and placed on the screens. Fruit should not be too ripe and juicy to avoid dripping (Detail will be in the next section).

Drying time

The length of time with any drying procedure depends on the water content of the food, the temperature and the humidity in the air. Tomatoes and fruit may take several days to dry. The interruption of the drying process at night is an advantage because fast drying produces crusts that obstruct a further withdrawal of water. Any crusts are therefore soaked during the night and the next day the drying process can go on unhindered (Detail will be in section) **Cover**

Food should not be exposed directly to the sun because it changes its colours. Therefore, the top drying screen should be covered with an empty screen or a lid with holes, keeping off flies at the same time.

Position of the dryer

It is not necessary to direct the solar dryer in the course of the day to the changing position of the sun. It is good enough to place it according to the highest position of the sun at midday.

TYPES OF DRYING PROCESSES

Several types of dryers and drying methods, each suited for a particular product and situation, are commercially used to remove moisture from a variety of food products including fruits and vegetables.

There are three basic types of drying process:

Atmospheric drying including batch (kiln, tower, and cabinet dryers) and continuous (tunnel, belt, belt-trough, fluidized bed, explosion puff, foam-mat, spray, drum and microwave) drying sub - atmospheric dehydration (vacuum shelf/belt/drum and freeze dryers)

While sun drying is practiced for certain fruits such as prunes, apricots, grapes and dates, atmospheric dehydration processes are used for apples, prunes and several vegetables. continuos processes such as tunnel, trough, fluidized bed and foam mat drying are mainly used for vegetable drying.

Factors for selection of a particular dryer/drying method include:

Forms of raw materials and their properties desired physical forms and characteristics of the dried product operating costs

ADVANTAGES OF DRYING

The major advantages of drying fruits and vegetables are given below:

Drying hardly affects the main calorie-providing constituents.
Dried fruits and vegetables have a longer shelf-life under proper storage conditions.
Transportation, handling and storage costs are substantially lowered.

They provide a consistent product, an important modern marketing requirement. They utilize the most economical and disposable form of packaging.

NATURAL SUN DRYING

Traditionally, sun-drying is carried out by spreading the product out on the ground and exposing it to the sun during the day and covering it at night to protect it from rain, dust and other damaging elements. Though open-air (natural) sun drying has been practiced for a very long time, there are many disadvantages associated with it: since the drying temperatures cannot be controlled, quality products cannot be obtained. The products cannot be safe from scavenging animals and birds. contamination by dust and other foreign particles, alternate drying and wetting of the product (during day and night) can cause cracking of the kernel, which in turn reduces the quality of the crop.

SOLAR DRYING

To have a valuable quality product and to minimize the wastage, artificial drying of the product should be employed. The earlier dryers used conventional fuels like electricity, coal and fossil fuel to heat ambient air for drying purpose. Drying of agricultural product is an energy intensive operation. High cost of fossil fuel and gradual depletion of its reserve has incited the use of solar energy as an alternative energy source for dryers. Solar dryers can find wide-spread applications in tropical and sub-tropical countries because of the following reasons: the amount of solar energy available in most cases is high enough to cover the heat requirement of small dryer units as well as the temperature level required for optimal drying of the crops. the technology is much easier to adapt than fully mechanized technologies. solar dryers can be easily constructed using local and cheap raw materials.

FACTORS GOVERNING SOLAR DRYING

Solar drying is a continuous process where moisture content, air and product temperature, and the humidity of air all change simultaneously along with the two basic inputs to the system: the solar insulation and the ambient temperature. The drying rate is affected by ambient climatic conditions. These include:

- Temperature
- Relative humidity
- Solar insulation
- Wind velocity
- Frequency and duration of rain-showers during the drying period

CLASSIFICATION OF SOLAR DRYERS

Various types of solar dryers have been developed in many countries over a long period. The solar dryers can be classified according to their heating modes, or the manner in which the heat derived from the solar radiation is utilized:

NATURAL OPEN-AIR DRYERS

These types of dryers are the simplest in construction. The agricultural product to be dried is placed on a tray or a mat and left to dry by ambient sunshine and wind. They have no protection against rain, dust and scavenging animals.

DIRECT SOLAR DRYERS

In this type of dryers, the product to be dried is placed on a tray or a mat and covered by a transparent plastic sheet or glass. The transparent material reduces the loss of heat. A thin layer of the material to be dried is placed inside the enclosure and exposed to direct solar radiation. Heat is generated by the absorption of solar radiation by the product itself as well as the heat build-up caused by the enclosure. The moist air is removed by natural convection. Covering the product to be dried reduces drying time and gives protection from dust and rain. Insect infestation and losses caused by birds and rodents cannot be prevented in this type of dryer.

INDIRECT SOLAR DRYERS

The collector heats up the drying air which flows through the dryer. The main advantage of using indirect solar dryers is that the crop is not directly exposed to direct solar radiation. This prevents the undesired discoloring while drying products such as apricots, apples and grapes. The crop is also protected from rain, dust, animals and insects. Therefore, indirect solar drying accounts for the production of high quality products.

DIRECT AND INDIRECT SOLAR DRYERS (MIXED MODE)

The combined action of the solar radiation incident directly on the material to be dried and of air pre-heated in a solar collector can also be used for drying agricultural products. This mixed mode dryer consists of a solar air heating collector and a drying chamber holding the trays for the crops.

HYBRID SYSTEMS

These are solar dryers which use another energy source such as a fossil or biomass fuel or electricity, to supplement solar energy in the drying process; e.g. for additional air heating during cloudy period. Hybrid dryers find useful applications in developing countries where the conventional energy sources are either scarce or expensive and where heat generating capacity of the solar system alone is insufficient.

SOLAR TUNNEL DRYER

The solar tunnel dryer was invented for use in sunny areas of tropical and subtropical countries and over the years, with some modification, it has become fully adopted to the
The solar tunnel is one of the few solar dryers that were successfully introduced for the processing of dried products. Nowadays it is used by different target groups and for drying of

most types of agricultural produce including fruits, vegetables, spices, medicinal plants and marine products. The dryer is used by research institutions, farmers and small co-operatives, womens' groups and small and medium sized businesses to produce anything from several hundred kg of dried products per season.

The solar tunnel dryer consists of a solar collector, drying tunnel, and a small radial flow fan. The crop to be dried is placed in a thin layer inside the drying tunnel. Heat is generated by absorption of solar energy on the absorber of the collector as well as on the crop itself. Air entering the solar collector is heated and this air is forced on the crop placed in the drying tunnel. This type of forced air circulation is made possible by using fans at the air inlet of the solar collector.

Cabinet type solar dryer capacity 5 kg

Natural Dryer capacity 10 kg

Semicircle type solar dryer capacity 15 kg

Biomass-solar hybrid dryer capacity 100 kg

Hybrid solar-biomass unglazed collector type dryer capacity 500 kg

Parabola dome dryer capacity 200-300 kg

Parabola Dome dryer capacity 1000 kg

Solar Tunnel dryer capacity 150 kg

Solar Tunnel dryer capacity 50 kg

Glass solar dyer capacity 50 kg

PCRET ACHIEVEMENT IN SOLAR DRYING

Several models of different capacities from 5 kg to 1000 kg Solar Dryers have been developed by this council and are being disseminated

PCRET designed developed and installed 10 unglazed collector type hybrid (Solar + Biomass) dryer having 500 kg capacities for drying of dates in Punjab, Khyber Pakhtoonkhwa, on Public Sector Development Program, Govt. of Pakistan
Designed Solar Dryer for Pakistan Tobacco Board for curing of tobacco,

Designed solar tunnel dryer 500 kg capacity for drying of Dates for Govt. of Sindh