INNOVATIVE SOLAR DRYERS FOR FRUITS, VEGETABLES, HERBS AND AYURVEDIC MEDICINES DRYING

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Abstract: Dehydration of fruits and vegetables is a promising food processing technology that increases shelf life of products for almost a year. It is a value addition process that can save 1/3rd losses of seasonal agro-products. Solar dryers can be used to carry food dehydration without relying on electricity. India is primarily an agriculture-dependent country. However, the pace at which agricultural and economic activities are changing is so fast that traditional methods of working are increasingly being considered out dated. Modernization, with many innovations, is the order of the day, such as progress in the field of information technology, which has gone forward in leaps and bounds. Indian rural economy is also improving at an accelerated rate with each passing day. The pattern of crops is changing fast with the farmers realizing that they cannot survive solely on conventional crops. This awareness is making farmers look towards horticultural crops such as fruits, vegetables spices, etc., which yield high income. In fact, rural women have also turned into successful entrepreneurs by starting cottage industries and microenterprises that fetch attractive returns through DWACRA and other Self Help Groups (SHGs).

Keywords: Solar Dryers, Convectional Crops, Horticultural Crops, Cottage Industries, Food Processing Technology, Agro-Products, Food Dehydration.

INTRODUCTION

Fruits and vegetables are an essential part of human diet providing micronutrients, vitamins, enzymes, and minerals. Most fruits and vegetables have a high moisture content and water activity. This makes them vulnerable to microbial and other spoilages due to biochemical reactions, such as enzymatic activity, respiration, and senescence. Therefore, preventive measures are taken to lower water activity; drying or dehydration is one such method. Drying is a process of removal of water from the food to inhibit biochemical processes and microbial growth. Drying increases
the shelf-life of the product, so that it can be available during off season. Drying can be done at high temperature, such as hot air drying or dielectric heating, at low temperature, such as freeze drying, or at ambient temperature, such as desiccant drying. Nevertheless, it is an energy guzzling process. With the depletion of fossil fuels and hike in energy prices, more and more emphasis is being given to utilize renewable energy sources for drying.

SUN DRYING

Since time immemorial, human beings have been using sun as a source of energy. This is one of the most prevalent and cheap methods practiced by most developing and underdeveloped countries, especially in tropics, where good sunshine hours prevail throughout the year. Food commodities are laid on a platform with intermittent stirring for uniform drying. The sun's heat not only reduces the moisture level as desired, but also kills insects present in the food product. Sun drying has certain limitations as it is dependent on the weather and sunshine hours. During uncertain rain and precipitation, the materials are not dried properly, which causes microbial growth and other qualitative deteriorations. The drying process usually takes a long time, thus causing infestation from insects, birds, and animals. Also, drying requires a large area. Despite these disadvantages, sun drying is still practiced in many parts of the World.

Fig.1 Drying Of Fruits and Vegetables

Solar Dryer

Over the years, the practice of open air drying or sun drying has become limited due to growing concern over quality of the final product. Due to high rise of fuel prices, depletion of fossil fuels, and emergence of modern and efficient but not so economic drying technologies, solar drying systems have made a place for themselves. The final product quality of a solar dried product may not be as good as freeze-dried product, but for the economically and energy deprived farmers and entrepreneurs, solar drying is the best in the business. Solar drying is achieved by direct sun radiation and greenhouse effect. The solar energy received by the drying chamber is dependent on the sunshine hours, climate, weather, atmospheric clearness, and location. According to E V Fodor, on a clear day solar radiation available to any location is dependent on the angle of the sun relative to horizon. Solar energy is free, renewable, abundant, and an environment friendly energy source. This reduces drying time due to effective utilization of solar energy. It maintains the quality of the food products and acts as an ideal substitute for fossil fuel based dryers. The two basic limitations faced by the solar dryers are sunshine hours and weather change. There are two types of solar driers; the Passive Type (natural convection) dryer and the Active Type (forced convection) or Hybrid Solar dryer. As per Ekechukwu, these solar driers may be again sub-grouped under three categories: (*i*) integral type (direct mode), (*ii*) distributed type (indirect type), and (*iii*) mixed mode. In a direct type, solar drying material is placed in a drying chamber having a transparent cover through which solar radiation enters and heats the food materials to be dried. In an indirect mode, solar energy is captured by a solar collector, which in turn heats the air. This heated air is then passed to the drying cabinet/chamber. In mixed mode, solar energy is collected in separate solar collector and heated air is then passed over the drying material. The drying materials absorb the solar energy directly through the transparent cover and walls.

Fig.2 Dried Tomatoes

Fig.3 Dried Bananas

Solar Natural Dryer

These are directly irradiated solar dryers, where the commodities absorb solar energy directly. The dryers are provided with transparent cover, such as glass or polyethylene. The upper layer is heated and dried by direct solar radiation and the subsequent layers are heated through conduction. Polyhouse or greenhouse drying is an example of solar natural dryers. Since the drying process is weather and sunshine hours' dependant, a constant drying temperature cannot be maintained. High outdoor temperature, low humidity, and clear skies are the ideal conditions for solar dryers. The inside air temperature of the polyhouse is about 20–30 °C warmer than the outside air temperature, which makes the drying faster as compared to open sun drying, thus reducing drying time. Pangavhane et al. have designed a solar dryer consisting of a solar air heater and a drying chamber. They observed that the drying time in a solar dryer was four days as compared to seven days in open sun drying and 15 days in shade drying for production of resins from grapes. A solar tunnel dryer designed for drying agricultural crops, by Bala et al., consisted of a transparent plastic covering the flat plate collector. The drying tunnel is connected in a series to supply hot air directly into the drying tunnel using two DC fans operated by a solar module. Bena and Fuller described that biomass-generated energy serves as a backup for such direct convection type natural solar dryers, thus improving the dryer efficiency.

Semi Artificial Solar Dryers

These are direct heated solar convective dryers. In these dryers, air is preheated b solar energy in a collector. The drying system usually consists of a solar collector and a fan for maintaining a specified air flow through the drying space. These driers are cheap to construct and can be employed where the drying material is not sensitive to periodic changes in the drying conditions caused by periodic nature of the solar radiation and changing atmospheric conditions. K Lutz and his co-workers had developed a multipurpose solar tunnel dryer consisting of a fan, solar heater, and tunnel dryer. The use of this dryer had reduced the drying time considerably with better end product quality.

Solar Assisted or Indirect Type Solar Dryer

In this type of dryer, solar energy is used to heat a fluid or sand pebble, which in turn heats the drying air. These usually have auxiliary energy source, such as a thermo-generator fuelled by biomass, natural gas or oil, to be used in situations where solar energy collected is insufficient for drying purpose. Better control of temperature results in a better quality product. The solar dryer developed by El-Sebaii et al. consisted of a flat plate solar air heater connected to a cabinet, acting as a drying chamber. The air heater is designed to insert various storage materials under the absorber plate to improve the drying process. Sand is used as a storage material. Since heat dissipated by sand is gradual, it reduces the drying time by 12 hours and the total drying time can be achieved in eight hours with suitable pre-treatment given to the fruits.

Hybrid Dryer

These dryers are usually direct-type solar dryers, but are backed up by an auxiliary energy source, so that during the less sunshine hours and cloudy weather the energy back-up can be utilized to dry food materials without interruption. This usually results in better product quality. Bhattacharya et al. have developed a hybrid solar dryer using direct solar energy and a heat exchanger. The dryer consists of a solar collector, reflector, heat exchanger cum heat storage unit, and a drying chamber. The drying chamber is placed beneath the collector. The dryer is operated during normal sunny days as a solar dryer and as a hybrid solar dryer during cloudy days. Drying is also carried out at night using stored heat energy, in which it is collected during the day time and with electric heaters located at water tank. The efficiency of the solar dryer is enhanced by recycling about 65 per cent of the drying air in the solar dryer. Under mid-European summer conditions, it can increase the air temperature 30– 40 °C above the ambient temperature.

Fig.4 Solar Biomass Hybrid Drying System

Fig.5 Greenhouse

CONSTRUCTION MATERIALS

For the frame, GI pipes, light-weight aluminum pipes or locally available materials such as bamboo, can be used to erect the structure. The covering material could vary from low thickness cheap polythene sheets, which is susceptible to photovoltaic degradation, erosion and wear, to expensive plastic, glass, and high density polymers that are resistant to photovoltaic degradation. Depending on the strength, the cover may last for one season to life long. Though glasses are durable, but during hailstorms they get damaged, and thus need replacement. While choosing the covering material solar transmittance should also be considered, apart from economics and durability.

MAINTENANCE

Rooftop solar collectors are very popular; they do not need extra space. The collected solar energy supplies heat energy to the drying chamber. Many a times, the collectors are mounted on the roofs which may not be suitably oriented to get maximum benefits from solar radiation. The collectors should be properly designed, considering the geographical location of the place. Proper insulation should be provided to the duct transmitting the hot air. The solar collectors should be cleaned regularly to maintain its efficiency. Maximum solar radiation reaches us during 10 am to 2 pm; hence, the temperature of drying will be more during this period. There will be a temperature variation in the drying environment as well as in the product. To maintain a constant drying air temperature, supplementary heat may be provided.

Advantages of Fruits & Vegetables Solar Dryer:

- Savings in time
- Increased production possible
- Less space requirement for drying
- More hygienic than drying outside in the sun
- Cost Effective
- Negligible maintenance costs
- Free and Clean energy
- Just one time investment, after that the energy is Free!
- Quick Return on Investment (ROI) - just 3 year

RURAL DEVELOPMENT AND WOMEN EMPOWERMENT

The Government of India launched many schemes and projects for creating job opportunities through rural employment guarantee schemes, poverty alleviation programs, 'Bharat Nirmaan', Prime Minister 'Grameen Sadak Yojana', 'Rajeev Yuva Sakthi' programs, etc. These are implemented at the village level by government agencies and NGOs. They consist of small enterprises, SHGs, and infrastructure development in several areas connected to rural development. In rural India, the main occupation of women and youth is based on horticultural operations. The horticulture crops consist of fruits, vegetables, medicinal plants, and other commercial plants, such as spices, etc. In recent times, the area of cultivable land under agriculture and horticulture has enormously increased due to the development of major and minor irrigation projects and modern methods of drip-and-sprinkle irrigation techniques. The volume of production from this sector is growing fast and post-harvest treatment of the product has become an important technology development program for value addition and preservation. Income generation schemes in the horticultural sector are most suitable and appropriate from the view point of stability of rural habitation. The manufacturing and associated commercial activity connected with the horticulture is providing proper solution for income generation and employment creation in the villages. Food processing technology is one of the priority sectors in our country. If this technology can be introduced at micro level in the villages, it would be a boon for rural women and youth.

DEVELOPMENT OF SOLAR FOOD PRODUCTS

In the last few years, intensive R&D work taken place by SEED for processing of fruits, vegetables, spices, herbs, forest product, chemicals, etc., using solar dryers for value addition and long shelf-life on a commercial scale. The dehydration process requires pre-treatments, addition of Class II preservatives
to enhance shelf-life, and fast drying to reduce the moisture levels. This process can be accomplished with zero energy cost, unlike the electrical dryers, in solar powered solar air dryers

CONCLUSION

A solar drying system, particularly for agro-products and marine products, is viable particularly in developing countries where labor costs are low and cost of fossil fuel energy is very high. In the future, larger systems could be designed utilizing solar, thermal, photovoltaic panels combined with wind power. As solar and wind energy is necessarily intermittent, advances in thermal and electrical energy storage is needed to make use of renewable energy viable in drying. To minimize use of oil or gas, biomass can be used for heating in the absence of insulation and wind. Farmers can use the locally available material for construction of solar dryers. The covering material should be carefully chosen.

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