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A SIMPLE SOLAR DRYING TECHNOLOGY WITH SPECIAL REFERENCE TO FARM LEVEL CHILLI DRYING IN SINDH PROVINCE OF PAKISTAN

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ABSTRACT

The cost-benefit analysis is based on the prevailing market prices for both the fresh and the dried products. Even if the technical performance of the dryer is found to be satisfactory, the use of solar dryer in Pakistan needs to be described from the economic point of view. Drying is an essential process in the preservation of agricultural products. Various drying techniques are employed to dry different food products. Each technique has its own advantages and limitations. Industrial drying offers quality drying whereas it's high cost limits its use. Open sun drying suffers from quality considerations though it enjoys cost advantage. Choosing the right drying system is thus important in the process of drying agricultural products. Especially, in the regions where some crops have to be dried during rainy season. In such areas special drying system has to be adopted Present study describes a comparison between traditional sun drying and other solar drying techniques and show that the use of solar dryer leads to a considerable reduction of the drying time and to a significant improvement of the product quality in terms of color, texture and taste. Besides, it also ensures the prevention of the infestations of insects and microbial pests.

Keywords: Chilli, Solar Drying, Crop Drying Technology, Sindh

INTRODUCTION

History shows that the civilization dawned upon the human beings when they learned about the art of producing crops and processing agricultural surpluses by drying them under the sun. The material to be dried was spread in the open air, on the ground or on a suitable platform for proper exposure. The method, though very simple, has some inherent problems. For example, this traditional sun drying method is weather-dependent and there is no shelter to protect the agricultural produce in the event of rain. The energy crisis in the early seventies stimulated investigations on solar energy utilization in countries with highly mechanized agriculture. In industrialized countries, solar technologies have to compete with efficient and reliable conventional technologies. Due to high energy prices, the use of solar energy is only economically viable in some niches such as solar drying of selected crops. The situation in developing countries is comparatively much better. High solar insulations, decentralized use, low energy demand and high fossil fuel prices favors the use of solar energy. The introduction of low cost and locally manufactured solar dryers offer a promising alternative to reduce the tremendous post harvest losses. This will have significant impacts on the food supply. The possibility of producing high quality marketable products can also improve the economic situation of the farmers (Muhlbauer *et al.*, 1993). Drying of agricultural crops in order to preserve perishable products is a highly acceptable technique, still widely used on a large proportion of the world's crops. Traditional methods of drying directly in the sun have been improved upon and many studies have developed drying methods and equipment that commercially dehydrate a wide variety of products. Sodha *et al*. (1987) state that no reliable estimates exist for the large post harvest losses in developing countries, but losses due to poor drying practices are estimated to be greater than 10% and may exceed 50% in some developing countries (Charter and James, 1993).

Hence, considerable losses of the product may occur during the drying process due to various external influences such as insects, birds, rainstorms and microorganisms. The quality of products may also be affected by contamination from dust, bird droppings, etc. Solar energy, because of its free and abundant availability, is still being used for drying of products such as fruits, vegetables, cereals, grains, skins, meat, fish, tobacco etc. As a result study of new drying methods become essential. The inability to adequately dry the product will, at the very least slow down the whole process and possibly lead to mould growth or discoloration. Any product with even a trace of mould cannot be used for processing. The sale value of moldy chilli can be less than 50% of the normal value. In extreme cases the whole crop can be lost; therefore, modifications have to be made in conventional techniques to address some of the prevailing problems.

With the exception of Northern areas, plenty of sunshine on an acre on a sunny day in an hour is equal to heat energy produced by burning 1600 kg of animal dung or 700 kg of firewood. The question arises weather is there any scope to use solar energy in the present technology period. Therefore, it is still a matter of great economy-A step towards self reliance to use solar energy for crop drying. There is ample scope to make improvements, so as to avoid demerits of the traditional techniques. In the present study solar dying of agricultural product is discussed with reference to chilli drying in Sindh.

DESCRIPTION AND DISCUSSION

Methods of Crop Drying Process:

Drying of product is the process of removing water from it, which means dried product is simply one with less water content. Biologically the process is known as dehydration. The dehydration of grain crops, like other products, proceeds by the movement of the water from the interior of the grains to their outer surface and then evaporating. The degree of evaporation of water depends upon the difference of vapor pressure of the drying air and that of grains. When both are equal, it is called an equilibrium vapor pressure and at that time, water content of grains remains constant and the process of drying stops. But, if there is pressure difference, the grain will lose water or gain moisture depending up on weather. Therefore, if the temperature of drying air is raised by only a few degrees, the relative humidity of even humid air is lowered enough for making it effective for drying.

In general, crop dryers can be categorized into two groups: traditional sun-drying and conventional drying methods. Traditional sun drying is a slow process, and losses may reach 30 to 40 % in tropical countries, the process requiring approximately 1 ha of drying surface per 20 ha of crop land. While conventional high-tech dryers have high efficiency and produce a uniform high quality product, they are expensive, and so not affordable by rural farmers. Thus, an alternative approach is to use a solar dryer that uses free solar energy available from the sun's radiation. However, at least ten years' meteorological data is necessary to obtain optimum performance of a solar dryer during different seasons. A comprehensive evaluation is necessary to determine the technical and financial viability before replicating the any type of solar dryer in Pakistan.

We can modify methods of drying to match the thermodynamic behavior of drying air with the help of psychrometric charts. These charts or graphs show relative humidity (R.H.) of the air at different ambient temperatures. Let ambient temperature of air be 25^{o}c and with 40 percent R.H. By reading the chart at point A (Fig.1), the moisture content of dry air is 8g/kg. Decreasing the temperature of drying air to 16.2^{o}c, with the assumption of adiabatic process, (a system without any entering or leaving of heat), the moisture content of the air increases to 11.5g/kg at point B (Fig.1). Therefore, with decrease in temperature, and additional moisture holding capacity of air will be 3.5g/kg. When it was calculated, it was found that, to evaporate 1kg of water from the products, a flow of approximately 285kg of dry air is needed.

In indirect method of solar drying, pre-heated air has been used. In this process, temperature of the air easily be raised up to 20-30^{o}C above the ambient temperature. For instance an increase of temperature is 20^{o}C i.e., the hot air temperature varies from 25^{o}C to 45^{o}C. Absolute moisture content of the air is again 8g/kg at 14 percent R.H. With the assumption of adiabatic process, at point D 100 percent R.H. of air is achieved with a lowering of temperature up to 22.5^{o}c and moisture content of 17.5g/kg. Now, to evaporate 1kg of water, the required quantity of hot air is reduced from 285kg to 105kg.

In our design for direct solar drying methods, glass sheets were used as a top cover. This way, infrared rays were made trapped in the drying chamber. Consequently, an increase in the temperature of drying chamber could occur throughout the process. In another case at an initial temperature of 25^{o}C and R.H. 40 percent with moisture content of 8g/kg there was an increase in air temperature by 5^{o}C. So, relative humidity of air fell to about 29 percent at point B, as temperature will not fall during the whole drying period. Therefore, relative humidity of air rises vertically and at point C it intersects 100 percent R.H. curve. Now, the moisture content of the air is 27g/kg. Hence we require only 52 kg of dry air to evaporate 1kg of water. Through analysis, we can choose an appropriate type of drying system with necessary modification and improvement according to climatic conditions of a specific site and requirements of the user. Following are some of the common methods of crop drying:

Natural Sun-drying

In the traditional or natural sun drying, the crop to be dried is to be placed on the ground and overturned intermittently, to expose all the material to the sun and air. In more advanced systems, the crop is placed on grills for an easy flow of air through it. But, in such a system the environmental effects such as rain, dew, dust microorganisms, etc. deteriorates the quality of the dried products. A solar dryer avoids these problems. The simplest type is the cabinet solar dryer, which can be constructed out of locally available materials e.g. bamboo, coir fiber or nylon weave. However, the construction costs are greater and a full financial evaluation should therefore be made to ensure that a higher income from better quality spices could justify the additional expense. During the wet season or times of high humidity, which often coincides with the harvest of the chillies, a solar dryer or sun drying cannot be used effectively. An artificial dryer, which uses a cheap energy source is necessary. This may be a wood or husk burning dryer or a combined wood burning and solar dryer. Figure shows a combined wood burning and solar drier, which is based on the McDowell Dryer and has been used in Sri Lanka.

Indirect Solar Dryers

This method is more suitable for dehydration of fruits and vegetables because it avoids all contamination. In this process, pre-heated air enters from one side of an opaque box, circulates inside the box and makes exit through the opposite side. Circulation of the air could be natural if forced. The products to be dried are placed on the racks. We can call it a conventional dryer, since air is being heated by solar energy instead of fossil fuel. Ekechukwu and Norton (1993) have described a solar drier where a chimney consisted of a cylindrical polyethylene-clad vertical chamber supported by steel framework and draped internally with a selectively absorbing surface. The performance of the chimney was monitored extensively

Direct or Glass Roof Dryer

This is commonly available solar dryer. It is easy to build and simple to operate, maintain and control. It can be used to dry a wide variety of agricultural products. This dryer is very useful and effective device for small-scale food preservation. Products to be dried are enclosed in a cabinet and with glass sheets on top (Fig.1). By this manner, temperature of the drying air and products is raised to enhance the rate of drying process. To promote circulation of the air, perforated side covers are used. One more interesting and developed form of this system is that of the glass roof dryer (Fig.1). It may be used for preservation of food on a large scale. It consists of two parallel rows of drying platforms with a central passage for an operator to move. A fixed glass roof above the drying platform allows the radiation of the sun to penetrate the dryer and also prevents the ingress of rain or dew at night.

Sun Drying of Chilli Crop

In Pakistan, both green (fresh) and dried chillies are consumed. Chilli is not only an important part of the diet but also one of the main cash crops. Considering the importance of chili in Pakistan and the need to dry them when they are available abundantly, there is a need to study improved drying systems that are reliable and affordable by the farmers of Sindh. Chilli moisture content of 70 to 80 % during the time of harvest and recommended a final moisture content of 8 to 10 % for storage and 4 to 5 % for grinding purposes. The recommended moisture content of fresh chilli to be 80 % full maturity and 8 to 11 % for safe storage. Chilli is normally dried on open ground with no shelter. This results in poor quality, associated with huge financial loss to the poor farmers. Studies have been carried out to estimate the loss of chilli from drying in this way and no alternative options have been investigated to improve the drying technique in Pakistan.

GENERAL PLAN FOR SOLAR DRYING

The cost-benefit analysis is based on the prevailing market prices for both the fresh and the dried products. Even if the technical performance of the dryer found to be satisfactory, the use of solar dryer in Pakistan needs to be tested from the economic point of view. Industrial drying offers quality drying whereas it's high cost limits its use. Open sun drying suffers from quality considerations though it enjoys cost advantage. Choosing the right drying system is thus important in the process of chilli drying. In the regions where some crops have to be dried during rainy season, special care is required in choosing the drying system. Studies comparing traditional sun drying and other solar drying techniques show that the use of solar dryer leads to a considerable reduction of the drying time and to a significant improvement of the product quality in terms of color, texture and taste. Besides, the contamination by insects and microorganisms can be prevented. A general research and development programmed for a solar drying system could be as follows:

1. Selection of an appropriate dryer design.
2. Identification of sites for field-testing.
3. Installation of dryer with active participation of the user.
4. Monitoring of dryer operation and user's reaction.
5. Operation of the dryer in comparison with traditional drying.
6. Collection and compilation of data such as weight of crop before and after drying. The drying time should
7. be noted for a suitable period, may be one year.
8. Evaluation of the results to assess the technical performance, economic viability and social acceptability of
9. the solar dryer.

10. Modification in the drying system, based on the feedback from the previous field-testing data, if needed.
11. A solar dryer, tested in the laboratories of an R&D organization, must be field-tested. It is only through this activity that a true assessment can be made of the suitability of the developed solar dryer.

Table 1. Comparison of Drying Techniques.

S. Nos.	**Drying Techniques**	**Advantages**	**Disadvantages**
1	Open air drying	Prior investment or fuel not required.	1. Products exposed to dust, rain, animals and ants . 2. Longer time required. 3. Labor involved for survey of products 4. Quality after drying not satisfactory .
2	Firewood or fuel drying	1. Quicker than that of open air dying.	1. Investment for fuel building & dryer box required 2. Smoke, forest degradation & products effected due to smoke drying ,often uncontrolled. 3. Labor required for operation and maintenance.
3	Electrical drying	1. Most rapid controlled drying. 2. Excellent quality of products obtained	1. Costly. 2. Operation/ Maintenance expensive. 3. Energy for drying often unavailable in rural areas. 4. Unaffordable for single /cooperative farming. 5. Building required for installation of dryer 6. Environmentally unfriendly with generator. 7. Literacy/knowhow required for operation.
4	Solar drying	Much cheaper . Easy to operate/Maintain. Specialized manpower not required. Controlled drying. Products quality controlled .Technology locally available and easily affordable. Fuel not required/ Environmentally friendly	Small investment required some know how required for quality of the products after drying.

Table 2. Cost comparison (in rupees) of solar dryers.

	Low cost solar dyer	**PV-powered solar dryer**	**AC-powered solar dryer**
Initial investment	100-200	500-1200	6000
Maintenance cost	10-15	50-60	100-300

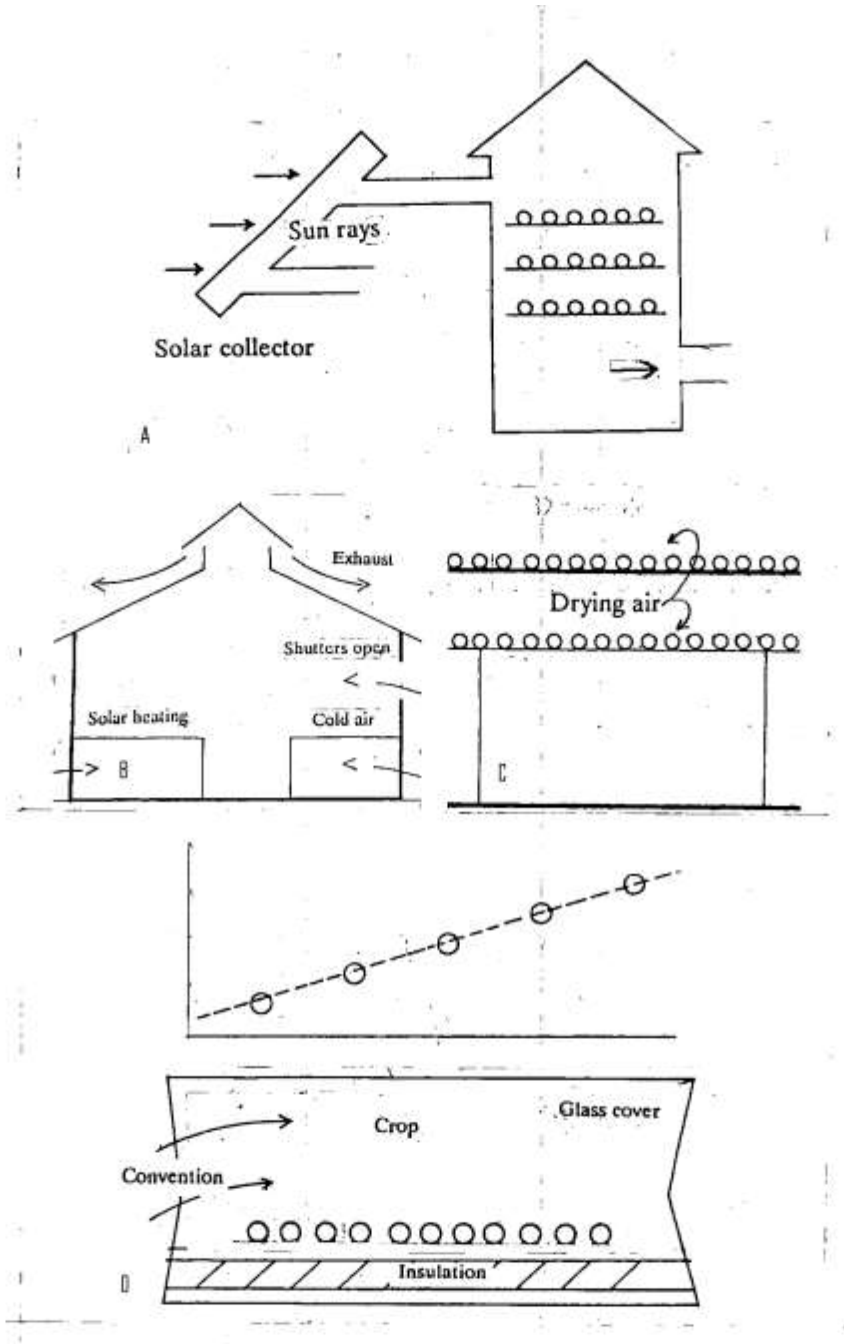

Fig. 1. Indirect dryer (A), Air circulating in the glass roof dryer for solar heating mode (B), Direct (Simple) and improved sun dryer (C) and mixed type solar dryer (D). Modified figure (Anwar *et al*., 1991).

Conclusive study for drying needs of farmers must be carried out. Surveys are necessary to obtain a more complete understanding of the drying problems. For example, studies are needed to estimate the quantities of crops which must be dried, losses of income due to inadequate drying, assessment of the capability and willingness of the farmers to invest in drying systems, possible dryer capacities and possibility of improving farmers` income through the introduction of improved drying system. To motivate the farmers, potential benefits of improved dryers must be practically demonstrated to them. The use of conventional drying systems would be too expensive for farmers. Thus, an alternative approach is to use solar crop dryers. This technique has been used in both developed and developing countries with some success. However, in spite of ample sunshine, solar dryers are not commonly used all over

Pakistan. The present technology provide at total crop drying requirements of the country. The economic benefits accrued thereof and the effects, if any, on the quality of the products, could encourage the farmers to use the improved techniques of solar drying.

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