EXPERIMENTAL PERFORMANCE OF SOLAR GREENHOUSE DRYER FOR DRYING VEGETABLES & FRUITS – A REVIEW

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ABSTRACT: Food drying is one of the most popular and oldest methods used for the preservation of food for later use. It is basically a process of moisture removal from foodstuff for storage purpose. Fruits and vegetables are most commonly agriculture products which have to be preserved for keeping the nutrition content high. Various methods are for preservation of food solar drying is one of them which are considered as the most common solar energy technology for increasing the storage life of food or agriculture product in different developing countries. The moisture content may cause microorganisms' growth which leads to decomposition of food. This paper is presented here to discuss the study performed on potential of solar drying technologies with applying new design of natural convection by considering specific local climatic conditions for the improvement of quality of products.

Keywords: Solar Drying, Fruits & Vegetables, Solar energy etc.

1.0 INTRODUCTION

Solar energy is the most attractive and abundant type of renewable energy source and solar thermal technology is rapidly achieving acceptance for reducing the conventional energy consumption in the field of agriculture applications. Drying fruits and vegetables is one of the oldest preservation methods that have received great attention due to high nutrition content. Solar drying is most attractive method used for preservation of food especially in India where most of the crops and grain harvests are lost to fungal and microbial attacks, by providing appropriate drying technique these wastage could easily prevent, which will enhance the storage of agriculture products. Solar drying is eco-friendly, cost-effective and inexhaustible source of energy which make it more beneficial because India is blessed with plentiful solar energy all the year round.

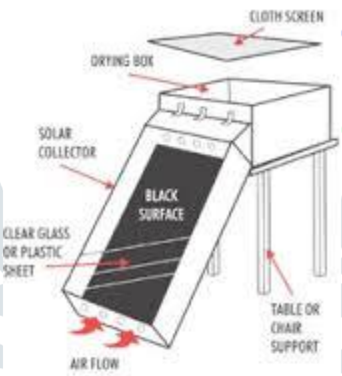

Figure 1: Solar food dryer

The solar dryer consists different components such as solar panel, battery, heating element and blower. The blower is employed for passing out the hot air to the required place, so that the vapour contents get removed. It delivers a better control over drying and the product obtained is of better quality than direct and open sun drying. Solar dryers are simply classified into following three categories such as:

- Direct Mode
- Indirect mode
- Mixed mode

2.0 LITERATURE REVIEW

Mamdoh Al-Busoul [2017] developed a new design of a natural convection solar dryer used to dry fruits is presented; taking into account the local climatic conditions prevailed in Jordan during summer season. The dryer will have a capacity of 100 kg of sliced apples and the simulation is based on mass and heat balances. It is deemed that such new design will be able to reduce the original moisture content, of the final product, to 10% within two days. The special tailored program could be used to calculate drying parameters for similar products under different climatic conditions. The next step will be focused on constructing the solar dryer in order to conduct actual experiments in the field.
Y. Baradey et. al. [2016] stated that drying is a water removal process from foodstuffs commonly used for preservation and storage purposes. Fruits and vegetables are the most important products in agriculture sector. As its contents of nutrition are very high, it has to be preserved. Keeping the products fresh is the best way to maintain its nutritional value. There are many methods for this preservation, but drying process is the most common method of food preservation because it increases the storage life. The moisture content in these products reaches, in some cases, more than 90%. Water content is considered the main reason for microorganisms' growth which leads to putrefaction. In this paper, the performance of a solar dryer for fruit and vegetables, using both natural and forced convection solar dryer,

was investigated and compared. Drying rate, weight losses, and removal of moisture content have been studied and analyzed. A comparison between natural and forced convection solar dryers has been done.

Dinesh Acharya et. al. [2016] described how the use of solar dryer is slowly finding its way for food drying in Nepal. The use of direct type dryer is being common for household purpose but the indirect type dryer still has limited application. This work is an attempt to evaluate the performance of the existing design of indirect type solar dryer. In this study solar rack dryer with drying capacity of 10 kg cauliflower per batch is used, however only 6kg of fresh cauliflower is used. Some known quantity of cauliflower is kept into the electric oven until it will bone dry. The difference between the initial and final weight of the cauliflower is the total amount of water contain. It can easily be built with commonly available Materials. The dryer uses corrugated aluminum plate as an absorber surface. The insulating material used is Styrofoam. The drying chamber has 6 trays with 1 door for material loading and unloading. The maximum efficiency of the dryer was found to be 30.14% after performance evaluation.

Anupam Tiwari [2016] experimented on the conventional drying system to preserve fruits, vegetables, grains, fish, meat, wood and other agricultural products is sun drying which is a free and renewable source of energy. But, for large-scale production, there are various known limitations of sun drying as damage to the crops by animals, birds and rodents, degradation in quality due to direct exposure to solar radiation, dew or rain, contamination by dirt, dust or debris. Also this system is labour- and time intensive, as crops have to be covered at night and during bad weather, and have to be protected from attack by domestic animals. There is also a chance of insect infestation and growth of microorganism due to non-uniform drying. The advancement of sun drying is solar drying systems in which products are dried in a closed system in which inside temperature is higher. Major advantage includes protection against flies, pests, rain or dust. Several significant attempts have been made in recent years to harness solar energy for drying mainly to preserve agricultural products and get the benefit from the energy provided by the sun. Sun drying of crops is the most widespread method of food preservation in most part of India and world because of solar irradiance being very high for the most of the year. As this technique needs no energy during day time, it is more beneficial to the small scale farmers who can't afford the electricity or other fuel for drying. If it is necessary to dry product in night or in bad weather, an additional bio-fuelled heater can be used for heat supply.

Satish Birbal Prajapati et. al. [2016] explained an indirect type forced convection solar dryer is fabricate with the components like evacuated tube collector, drying chamber and blower. The performance of the designed drier is evaluated by carrying drying experiments with copra at Coimbatore district Tamilnadu, India. A short survey of these showed that applying the forced convection solar dryer not only significantly reduced the drying time but also resulted in many improvements in the quality of the dried products. Solar drying of copra is carried for forced convection and is compared with natural convection solar drying. The temperature of the drying chamber ranges from 49ºC to 78ºC for natural and forced convection while the ambient temperature ranges from 28ºC to 32ºC. Initial moisture content of copra ranges from 51.7% to 52.3% and the final moisture content obtained about 7 to 8%. The forced convection solar dryer takes less time than the natural convection solar dryer to attain the equilibrium moisture content. Solar drying copra obtained was free from smoke, dust, bird and rodent damage.

Ms. Vaishnavi Bharat Chougule et. al. [2016] presented the study on drying crops by solar energy is of great economic importance the world over, especially in India where most of the crops and grain harvests are lost to fungal and microbial attacks. Proper drying could easily prevent these wastages, which enhances storage of crops and grains over long periods. India is blessed with abundant solar energy all the year round. Drying is one of the important and most energy consuming processes in the food processing, chemical, printing, fabric dying industries, etc. In farmer level drying is being done on open yards without any good hygienic conditions. Generally thermal energy, maintained between 45 0C to 25 0 C depending on the products and production methods. A conventional fuel like electricity, firewood, diesel, furnace oil, kerosene, etc is producing that energy. The objective of this project is to modify design of a forced convection indirect solar dryer and its performance test on Grapes. The system consists of an air heating section. The solar dryer consists of different components such as solar panel, battery, heating element and blower. The blower is used to passing the hot air to the required place, so that the moisture contents in the place was removed. It offers a better control over drying and the product obtained is of better quality than sun drying. Solar Dryer can be operated at higher temperature, recommended for deep layer drying.

M. Manoj et. al. [2013] described drying is an excellent way to preserve food and solar food dryers are appropriate food preservation technology for sustainable development. The aim of the work is to develop a MATLAB-based modeling and simulation to predict the air flow properties, equilibrium moisture content of the solar dryer technology for food crop drying especially cocoa and other cash crops. In the model practical and technological ways by which the Crank – Nicholson equation is applied to heat equations using finite difference method to develop a solar dryer utilizing Green House Effect (GHE) for drying cocoa beans. The mathematical model for the general case of the 3D (three-dimensional) conduction equation for green house dryer has been derived and simulated by Matlab program.The results show that the dryer performed at it optimal range and dried beans within 7 days to a moisture content of 7% to the weight of the bean. A mathematical model was developed to predict the performance of the green-house effect type solar dryer and the 3D modeling was drawn using ProE.

Umesh Toshniwal et. al. [2013] demonstrated the unpredictable rise and frequent scarcity of fossil fuel accelerated the continuous search for an alternative power source. Solar is one of the renewable and sustainable sources of power that attracted a large community of researchers from all over the world. This is largely due to its abundant in both direct and indirect form. As such the development of efficient and inexpensive equipment for the drying of agricultural and marine products using solar power evolved thereby improving the quality of the products as well as improving the quality of life. The use of solar dryers in the drying of agricultural products can significantly reduce or eliminate product wastage, food poisoning and at the sometime enhance productivity of the farmers towards better revenue derived. A solar crop drying system does not solely depend on solar energy to function; it combines fuel burning with the energy of the sun, thus reducing fossil fuel consumption. In this paper a review of the solar dryer is presented. The various design of the solar dryer is reported in the literature thus far is presented.

Akinola A. Adeniyi et. al. [2012] experimented on growing preservation technique in western part of Nigeria is the use of solar dryer box. Conventionally, exposure to direct sun light has been the practice to preserving farm produce because majority of the farmers cannot afford advanced techniques that may depend on electricity supply from the national grid. Recent studies have shown that alternatives to direct exposure to the sun are preferable for vitamin preservation. A simulation of a solar box design for such purpose is presented for temperature distribution based on sun direct solar irradiation of 1423W/m2 of Akure (5.304º Latitude 7.258º Longitude). Results compare well with experiment.

J. Kaewkiew et. al. [2012] conducted study on solar drying which is considered to be a useful solar energy technology for developing counties. In this work, the performance of a large-scale greenhouse type solar dryer for drying chilli was investigated. The dryer has a parabolic shape and it is covered with polycarbonate sheets. The base of the dryer is a concrete floor with an area of 8u20 m2. Nine DC fans powered by three 50 W solar cell modules were used to ventilate the dryer. The dryer was installed at Ubon Ratchathani, Thailand. Three batches of chilli were dried in the dryer. It was found that five hundred kilograms of chilli with the initial moisture content of 74% (wb) were dried within 3 days while the natural sun dried needed 5 days. The chilli dried in this dryer was completely protected from insects, animals and rain. In addition, good quality of chilli was obtained.

P.P. Bhor et. al. [2010] experimented on locally available fish variety Dhoma was selected for evaluation of solar tunnel dryer. These selected fish were treated with salt and without salt before drying in solar tunnel dryer and open sun drying. Drying rate was higher in solar tunnel dryer compared to open sun drying due to higher temperature (53.50C) attained. Time required to reach safe moisture content was observed. Drying time required for salted fishes was more compared to unsalted fish. In case of the fish sample with salt treatment moisture content reduced upto 19.29 % (d.b.) within 35 hours for upper tray, 19.63 % (d.b.) within 37 hours for lower tray and 19.41 % (d.b.) within 39 hours for open sun drying. While for the fish sample without salt treatment moisture content reduced upto 19.05 % (d.b.) within 32 hours for upper tray, 19.90 % (d.b.) within 35 hours for lower tray and 23.73. % (d.b.) within 37 hours for open sun drying. In open sun drying method, moisture absorption during night was higher than solar tunnel dryer. In solar tunnel dryer contamination due to insects, birds, wind and the animals were not found as in case with open sun drying.

B. K. Bala et. al. [2009] has documented this paper which presents developments and potentials of solar drying technologies for drying of fruits, vegetables, spices, medicinal plants and fish. Previous efforts on solar drying of fruits, vegetables, spices, medicinal plants and fish are critically examined. Recent developments of solar dryers such as solar tunnel dryer, improved version of solar dryer, roof-integrated solar dryer and greenhouse type solar dryer for fruits, vegetables, spices, medicinal plants and fish are also critically examined in terms of drying performance and product quality, and economics in the rural areas of the tropics and subtropics. Experimental performances of different types of solar dryers such as solar tunnel dryer, improved version of solar tunnel dryer, roof-integrated solar dryer and greenhouse type solar dryers which have demonstrated their potentialities for drying fruits, vegetables, spices, medicinal plants and fish in the tropics and subtropics are addressed. Simulated performances of solar tunnel dryer, improved version of solar tunnel dryer and roof-integrated solar dryers were assessed for drying fruits, vegetables, spices, medicinal plants and fish. The agreement between the simulated and experimental results was very good. The simulation models developed can be used to provide design data and also for optimal design of the dryer components. A multilayer neural network approach was used to predict the performance of the solar tunnel drier. Using solar drying data of jackfruit and jackfruit leather, the model was trained using backpropagation algorithm. The prediction of the performance of the drier was found to be excellent after it was adequately trained and can be used to predict the potential of the drier for different locations and can also be used in a predictive optimal control algorithm. Finally, prospects of solar dryers for drying fruits, vegetables, spices, medicinal plants and fish in the tropics and subtropics are discussed.

M. A. Hossain et. al. [2005] documented this article to present modelling of solar tunnel drier by taking into account heat transfer in the collector and coupled heat and mass transfer with in the drying unit. One set of equations was developed to predict cover temperature, absorber temperature and air temperature in the collector and another set of partial differential equations was developed to predict the air and chilli temperatures and moisture content for drying of green chilli in the solar tunnel drier. First set of equations was solved iteratively and the second set of equations was solved numerically on the basis of an exponential solution over the finite difference grid element using the outlet air conditions of the collector as inlet conditions of the drying unit. The simulated air temperatures in the collector and the drier agreed well with the observed air temperatures. Good agreement was also found between experimental and simulated moisture contents for drying of green chilli.

B. Khiari et. al. [2004] conducted study on solar drying, an energy-saving process, is an efficient food conservation solution for countries that often have only sun as an energy source. Decreased energy requires for a drying and improved dewatering process result from lower moisture fraction. This investigation focuses on the study of water behaviour inside the product to be dewatered in the particular ease of a tunnel drier, and on the evolution of water content during the whole process starting from evaporation and ending with evacuation of the humid air. The mass transfer of water was respectively studied, analysed and simulated as to apprehend better the mechanisms governing drying and to build a real simulation tool to help in the design and automation of tunnel industrial driers. Space and time profiles of water content led to the assessment of drying velocity during the different phases and consequently to the comprehension of quantitative analysis. The kinetics obtained with the model under different working parameters (temperature, pressure, reactor time residence) and within various initial and boundary conditions show good agreement with those obtained experimentally.

B.K. Bala et. al. [2001] has performed field level experiments on solar drying of pineapple using solar tunnel drier were conducted at Bangladesh Agricultural University, Mymensingh, Bangladesh. The drier consists of a transparent plastic covered flat plate collector and a drying tunnel connected in a series to supply hot air directly into the drying tunnel using two dc fans operated by a solar module. This drier has a loading capacity of 120-150 kg of pineapple and a total of 8 drying runs were conducted. In all the cases the use of solar tunnel drier leads to considerable reduction of drying time in comparison to sun drying. The pineapple being dried in the solar tunnel drier were completely protected from rain, insects and dust, and the quality of the pineapple dried in the tunnel drier was of quality dried products as compared to sun dried products. Proximate analysis also indicates that the pineapple dried in the solar tunnel drier is a good quality dried product for human consumption.

3.0 CONCLUSION

Above study of literature review clearly represents solar dryer can be extensively used for agriculture applications and various research works have been conducted for improving the performance and drying capacity of dryers for different agriculture materials. After conducted a deep study it is found that experiments were conducted with different food materials and convection types only so here in this study a black surface is used for improving the absorbing capacity for performing forced convection in solar dryer.

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