WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on the Indirect Solar Dryer with Thermal Energy Storage and PV Panel

Durgesh Singh[a], Vikash Dwivedi[a]*

[a]*Department of Mechanical Engineering, B. N. College of Engineering and Technology Lucknow (U.P) – 226201,India*

A B S T R A C T

In many parts of the developing world, building an efficient and cost-effective solar dryer with a thermal energy storage system for continuous drying of agricultural food items at a constant state and moderate temperature (40–75 0C) has become a feasible alternative to fossil fuel. Solar energy storage can help to shorten the period between energy supply and demand, which is important for energy conservation. Because the conserved technology is insufficient and the storage procedure is not ensured, the quality of agricultural goods will have degraded.With new approaches in manufacturing procedures, postharvest losses have been eliminated. Drying is used to preserve both food and agricultural products. The use of the sun's energy for drying has been done in the past. Solar dryers are available in a range of designs and capacities in the agriculture industry. An indirect solar dryer (ISD) is one of them, however it has the disadvantage of not being able to function after sunset. Techniques for extending its operation during off-sunlight hours to improve performance have not been thoroughly examined. The purpose of this review is to evaluate the characteristics and benefits of sensible heat storage material (SHSM) in ISD.The most common kinds of ISD with SHSM are discussed, as well as a review, discussion, and tabulation of the findings on ISD with various sensible heat materials. It is possible to design a solar dryer system that uses thermal energy storage materials with high thermal efficiency and reasonable costs as a possible fossil fuel alternative in both developing and developed countries. The drying process in ISD for agricultural produce may be done during off-sunlight hours, which was previously impossible with a traditional solar drier.As a consequence, sun drying agricultural goods with sensible heat storage materials helps to conserve energy while also improving solar system efficiency.

Keywords:Solar energy, Thermal energy storage,Indirect type solar dryer, Heat storage material, Food preservation.

1. Introduction

Solar energy is the essential source of all renewable energy. The sun is a huge source of energy and earth capture energy approx. 1.8xl011 MW, which is multiple thousand times bigger than the general energy use rate on the earth [1]. Hence forth this can fulfill the requirement of energy in the present and future wishes of this planet. Thus, it is one of the most extreme promising sources of energy. Dislike petroleum products and atomic power, it is a naturally clean form of energy supply. Besides, it is free and accessible in sufficient amount in all place of the region where in maximum number of populations stay. Solar energy is more powerful position as compared with conventional energy [2] [3]. In a tropical nation like India greatest of the energy demand might be met by methods of use of simple system that can change over solar energy into usable form of energy. Solar energy is delivered by the sun due to the response of hydrogen atom to changing into helium particle and generate large amount of energy. The distance between sun and earth is 150 x 106 km and temperature of sun surface increases up to approx. 6000°C. Due to the high temperature of the sun, the energy is discharge by radiation to the environment [4] [5]. For financial related improvement of a country, energy plays an important role. Sources that are simply available, accessible and eco-friendly are used for financial related improvement in the future of the country in the aspect of energy. Two types of energy are available in the world, one is renewable energy and other is non-renewable energy. In present circumstance our existence is standing up to two major troubles: one is to deal the exponential demand of energy in the development of country and other is to deal global regional and local environmental impacts coming out from supply and use of conventional energy. The Non-exhaustible power source is the kind of solar energy and conventional is coal, Oil and LPG etc. The renewable energy is promising a solution to the issues for keeping up the current state of human progress [6] [7]. In the above conclusion, we find that the utilization of renewable energy assets ought to be completely fulfilled the requirement of energy and this will build the accessibility of energy for future individuals. Renewable energy supply has also played an important role in extending development to the agriculture

* *Corresponding author.*Tel.: +91-6394897392;
E-mail address:*ds1904310405009@gmail.com*

technology in developing countries to extend their productivity [8-11]. The power production in view of different assorted kind of essentialness in India up to 31 April 2021 is given by following the pie chart and table 1:

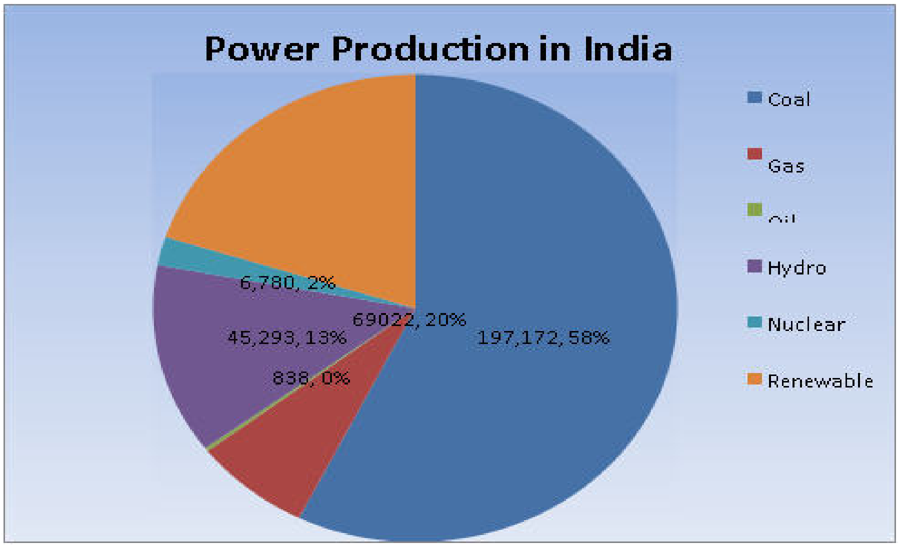

Fig.1- Electricity production in India [2]

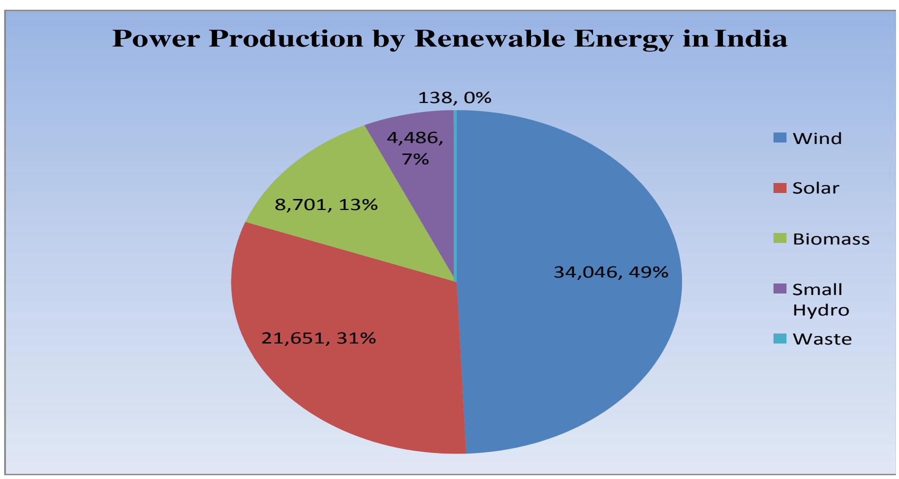

Fig. 2- Electricity productions in India by renewable energy [3]

Table1- Power production in India [2,3]

Energy	MW	% of total
Total Thermal	222907	64.8%
Coal	197172	57.3%
Gas	24897	7.2%
Oil	838	0.2%
Hydro(Renewable)	45293	13.2%
Nuclear	6780	2.0%
RES	69022	20.1%
Wind Power	34046	9.9%
Solar Power	21651	6.3%
Biomass Power	8701	2.5%
Waste to Power	138	0.04%
Small Hydropower	4486	1.3%
Total Power	344002	100%

Food scientists concluded that food is prevented from bacteria, yeast, and enzymes if the moisture constituents in the food are lowered in between 10% to 20% by wet basis. The flavor and most of the nutritional value is also preserved and concentrated [12-15]. Commonly used method for drying crop in developing country is open sun drying. In this process, the drying is by using shorter wavelength and also using the process of natural convection as the crops lie on the ground, due to this method the process is the cheapest and easily available as the source of energy is the sun. Among these limitations is the augmentation in crop loss due to partial drying which leads into fungal infection, worms, birds and rodent's germination, variability in climate and sudden weathering. Moreover, the ability of the sun to dry is a function of numbers of factors; therefore, uniformity is not easily achieved. Due to these inadequacies in O.S.D, it has led to the development of solar drying techniques. Solar drying provides products with more energy as compared to open sun condition hence increasing the vapor pressure of the moisture within the crop. Some different analysts were detected that different material properties of various kinds of PCM under different conditions and its applications in solar-based energy storage. A typical solar dryer better upon the normal O.S.D system in four necessary ways in which [13-20]:

i. It is quicker. Materials will be dehydrated in dryer take less amount of time as compared to open sun drying. Solar dryers reduce drying times in two ways. In which, Firstly the transparent coating over the system intercepts heat within the dryer, elevating the temperature of the air. Secondly, the increasing the incident area of radiation that permits for larger insolation is found.
ii. It is more efficient. Time required for drying of a product is decreased and the number of crops lost to decay is lowered after harvesting. Using the solar dryer, a bigger percentage of food is saved there for human consumption.
iii. It is hygienic. Since controlled drying takes place hence less chance to be contaminated by pests and reducing the chance of the growth of toxic fungi.
iv. It is healthier. Drying materials have retained their nutritional value such as vitamin c due to drying at the controlled environment. A new bonus is that crop can look better which boosts their market in the region and therefore provides higher money returns for the farmer.

The aim of this investigation is to build up an indirect solar-based dryer during which the crop is dried by the stream of hot air in drying chamber. The issues of low and medium scale load might be solved if the solar dryer is design and constructed with the consideration of limitations. The advantage and disadvantage of several solar dryers given below:

Types of dryer	**Advantage**	**Disadvantage**
Direct sun	• Lessexpensive • Simple	• Damage food by UVradiation
Indirect sun	• Protection of product fromUV • Negligible damage from environmenttemperature.	• More complex • In comparison of thedirect solar dryerexpensive.
Mixed mode	• Less damage of product from extreme temperature	• More complex and expensive than directsun • Damage food by UVradiation
Hybrid	• Without solar energy canbe operated • Food lossminimum • Better control ofdrying • Fuel mode dryer faster thansolar	• Expensive than othertype. • Dependence onfuel.

So, along the above lines, this work will be upheld the importance of indirect mode solar-based drier that is reliable in simplicity and economically, constructed using of locally available materials and to check the execution of this solar dryer.

For the drying method and the improvement in the dryer, characteristics simulation plays an essential role. Many problems are associated with the moisture transfer of crop represented in the mathematical term. Analysist are stated that the moisture transfer in solid and crop are usually decreases as increasing dry time. Some assumptions about relating to the dryer are product geometry, mass diffusivity and conductivity can lead to some problems in defining the solar dryer character. Fick's second law is used in semi-theoretical approaches for design and construction of reliable solar dryer (Hazbavi et al., 2013). On the other hand, the analysis of drying of hazelnuts is taken to consider by five semi-theoretical and two empirical data and compare to the predetermined range of result within range of temperature 100-160°C (Ozdemir and Devres,1999). In this literature, examine the air temperature moisture, flow rate of air and drying rate of the dryer. It compares between the Indirect solar dryer performances with the performance of open sun exposed product. Karathanos and Belessiotis (1999) investigated about the high-sugar such as currant, sultana, fig, and plum are coming under the thin-layer process for drying the horticulture product. For determining the performance of the thin layer products such as fresh fruits, and shelled and unshelled pistachios, a mathematical model is developed who is reliable in the process and for modeling use Page equation. Lahsasni et al. (2004) examine about the prickly pear peel as the thin layer crop in the forced circulation dryer. Midilli–Kucuk (2003) was test the natural circulation dryer that gives a better experiment data as compared to previously given data of Doymaz, who investigate the performance of the black grapes in solar dryer who are situated in laboratory dryer. For defining the performance of black grapes, the equation is used given by Page. Yazdani et al. (2006) test on the pistachio and define the sorption isotherm of the product by the six varied model and also find the result is an experiment. The nearest or very less difference in between the experiment result and Smith model result is on the sorption isotherms of pistachio. The heat taken by pistachio for vaporisation of water was finding by using Clausius-Clapeyron equation at different- different temperature. Guine (2008), test was done on the pears which are at different operating condition. The purpose of this was an experiment in the evaluation of previously solar dryer by applying the diffusion-based model. The performance and properties of pear have examined by use of continuous convection dryer.

Since drying commonly use the strategy of thermally removing substances moisture up to the maximum point of a solid product. According to Sodha et al , drying depends upon the rate of moisture transfer inside the product that moves to the surface by diffusion method depending upon the kind of product. There are three modes of drying OSD, ISD, and DSD in presence of solar power. An effort has been created by Anwar and Tiwari for O.S.D for various crops using linear regression analysis. It's been discovered that convective heat transfer varies considerably from crop to crop because of the presence of various levels of moisture content. Their results are inside dryer 6-16% range uncertainty and in open environment 35% uncertainty in Kabuli chana.

Pawar et al. planned and manufactured a huge scale constrained convection solar based drying framework containing a variety of forty solar based collector and three drying trays with a blower .it had been shown that use of this category system was reliable and had a capability to save lots of giant amounts of fuel. It keeps the item clean and takes less time for dried a product than in OSD.

Wang et al. 20017 performed a practical test on a flat plate solar collector for defining the performance of the system in presence of thermal storage. In this experiment, analyze the result which is coming to experimental data and a newly developed model gives the satisfactory result. The heat extraction power increases and the heat extraction time decreases with increase in the volume flow rate of HTF. In the study, it was found that when the volume flow rate increased from100 m3/h to 150 and 200 m3/h, respectively, the heat extraction power will increase by 10% and 26% and the heat extraction time will decrease by 8% and 20%.

Akinola et al. 2006 [24], constructed an unbiased evaluation of a mixed mode solar dryer. The concluding investigation of the dryer has shown that in addition to drying the cabinet drying more effective than sun drying as well as energy is also saved. It has an average energetic capacity of 50% and a thermal efficiency of 66.95%. Gupta et.al 2008.

the absorber plate of solar wind heater and their characteristics changes is defined by the complete analysis of various types of artificial roughness geometry present on absorber plate. The dryer was design, fabricated and tested at different-different condition. It was showed that after apply blower the temperature was reduced but mass flow rate increase of air. Srivastava et al., built up a mathematical model to analyze the thermal characteristics of four varied types of solar wind collectors in specific environmental conditions. This experiment is related to the experimental inspection of a thermal attribute of the SDS for a clear day in an overall climate. Experimental data has been saved for a period of seven hours a day for two days. To determine the impact of air mass flow rate on the thermal performance the information is taken throughout the day once radiation doesn't vary from 10:30 AM o'clock to 11:30 AM o'clock. The experimental information obtained through measurement for the most common day is done using the first law efficiency and second law efficiency approach so that collector efficiency and dryer efficiency and air mass flow rate can be determined.

The ideas of solar radiation energy during the rainy season or while solar energy availability is inadequate and to be become always the factor of attraction amongst researchers. Among numerous thermal energy storage techniques, LHS is mainly used as comparing sensible heat storage due to provide an excessive energy storage density and its capability to keep energy at a steady temp to the phase transition temp of the energy storage substance. Since the behavior of solar irradiation energy is highly irregular, unpredictable and available only during some daytime hours hence its application requires efficient THS so that in night gives the energy which is stored in day-time [10]. Literature exhibits that examine the feasibility of the use of [LHS] with paraffin wax as a phase (PCM) exchange to extra sun energy and launch it when the provision is inadequate or no longer available. Sharma et al. 1999 [27], attempted to find an appropriate PCM for different purposes a reasonable heat exchanger with approaches to improve heat exchange to give an assortment of plans to store the heat utilizing PCM for various applications.

Khudhair et al., has looked into the work on energy protection in building applications with warm energy stockpiling by inactive warmth utilizing PCM materials Energy storage in the walls, ceiling and ground of a constructing can be more desirable with the aid of encapsulating suitable PCM substances within those surfaces that seize the solar energy from inside wall of room at once and increases human comfort via reducing the frequency of inner temp swings and so temp is maintained towards the favored temp for an extended period of time.

Alkilani et al. (2009) has an investigation of a thermal attribute of the exit air from a PCM unit consisting of containing a mixture of paraffin wax and Al powder using of cylinder type collector.

Shukla et al., has done an experiment on drying of open house and greenhouse and has evaluated the convective heat and mass transfer coefficient as the depending on climatic parameters. It was found that there was more heat and mass transfer in OSD comparison to a natural convection greenhouse drying. However, its value more in forced circulation greenhouse drying in compare with natural mode O.S.D. The goal of the investigation is to predict and verify the thermal model of the dryer with PCM as energy storage and alternative energy backup system.

Bansal and Buddhi designs constructs and investigate the performance of solar dryer with incorporate PCM for energy stored in the solar collector. The research on the incorporation of PCM stockpiling with sun-oriented is less published. Enibe examined the execution of a characteristics sun-based air warming framework with PCM energy stockpiling for product drying and egg incubation. In that review, PCM was set up in modules with the module'sequipage over the absorber plate. Not the much work has been performed on constrained flow sun-powered dryers with PCM stockpiling. In the present examination, the forced circulation solar dryer with use of PCM container has examined. A PCM container was created likewise to a shell and tube heat exchanger. The manufactured compartment was put in a solar-powered dryer and studies were directed on with and without loading the item into the dryer. The charging and releasing of PCM have additionally been explored.

Mohan raj et al., were designed and constructed an indirectly forced convection solar dryer combined with PCM for chili drying. The using of phase change material prolonged the drying time with the aid of approximately 4 hr. in keeping with the day. The moisture content of chili reduces 72.8% (wb) to become 9.7% and 9.2% (wb) in the lower and upper zone of dryer respectively at some stage in the drying procedure. The thermal efficiency of set-up was expected at approximately 21% and specific moisture extraction charge changed into estimated at approximately 0.87 kg/kW h. On the starting of drying the exit air humidity value were larger increases by using approximately 89 % and, it reduces as time expanded. In the final stage of drying the outlet air temperature, air humidity has become constant at approximately 60% as time increases the drying rate reduces.

Kumar et al. (2017) was performed an analysis on characteristics of green chili with the use of varied dryer. They had use tray type dryer and hot air oven dryer for drying chili at 50°C, 60°C and 70°C of varied temperature. They found that in dryer initial moisture content of chili reduce from 84.20% (wb) to 10.35%, 8.41%, 9.71% at 50°C, 60°C and 70°C in 10,10 and 9 hours in respectively. In hot air oven the moisture of green chili reduces from 84.20% to 15.28%, 13.66% and 15.17% at 50°C, 60°C and 70°C in 12, 12 and 11 hours respectively. They had seen that the hot air oven taking more time as compared solar dryer.

Andrew et al. (2013) investigates an indirect natural convection sun-powered dryer utilizes biomass reinforcement burner set up PCM for drying pepper berries. The point of the biomass reinforcement burner was to reduce the drying time and counteract molds developed on dried items. The created sun-powered dryer took 11 hours of daytime sun radiation and 6-hour periods of the evening time with biomass consuming for drying berries and dried items were of high nutritive quality. It took 5-7 days for the same drying process for solar technique and was depending on the accessibility of sun-based radiation.

Kumar et al. (2011) determine the coefficient value of heat transfer in the solar dryer and O.S.D of papad in open sun and indoor forced convection drying modes are 3.54 and 1.55 W/m2°C. The Nusselt number equation was solved by using linear regression analysis.

Muazu et al. (2012) investigation the performance a built forced air–convection frits and vegetable dryer of 20 kg ability including tray dryer, heat exchanger, air blower and combustion chamber. The use of okra of sliced length 3mm and 6mm and 3mm for tomatoes, there was a reduction in drying time as towards O.S.D.

Lamharrar et al. (2015) was studied drying performance of the thin layer forced solar dryer of herba-alba of North Africa. In Morocco, this plant is utilised in a diabetes remedy. The solar drying is effective for retaining the nutrition value of horticulture products, so it was essential to know the process of drying and storage for Artemisia herba-alba. The drying nature of Artemisia herba-alba turned into investigated within the ranges of 28 to 39°C of ambient air temperature, 50°C to 80°C of drying air temperature, 30 to 33.5 %, of relative humidity and 0.056 m3s-1 of drying air flow rate. Then statistical models had been tested for becoming the experimental drying curves. The Midilli-Kuck model has used for dying the curves of Artemisia herba-alba. The drying performance is in this type of solar dryer depending upon air temperature.

Ayushi Singh (2016), A natural convection mixed mode solar dryer was designed, fabricated and tested under various conditions of loading and collector. The water content of potato is reduced from 80-85% to 3% of wet basis. The temperature of the rectangular pipe collector was finding 10-43°C greater than the ambient air temperature in between 10 am to 1 pm.

Vijayan (2005) was fabricated and performed an experiment on forced convection indirect solar dryer for drying potato sliced at Coimbatore Institute of Engineering and technology. They also compare the characteristics of dryer product with open sun. The moisture content of potato was reduced from 85% to 14% at constant mass flow rate 0.058 kg/s within the drying period 4 hours, whereas open sun drying taking 5 hours for drying potato sliced with same boundary condition. The efficiency of solar was found in between 20% -32% ranges.

Hossam et al. (2017), experimentally performed the performance of HDH desalination machine with a new zigzag packing made from aluminum sheets. The execution of an indirect solar oriented dryer combined with HDH desalination framework studies. The performance of the proposed framework is tentatively examined. Use the two- stage dryer stepped forwards the MR by 71.78% in comparison to single stage dryer.

Wang et al. (2017), Investigated, an indirect constrained convection solar-powered dryer with the assistant heating device has been used in mango sliced drying. The dryer comprises a tube sunlight-based air collector, fan, PCM container, drying chamber, and control framework. The particular moisture extraction rate (MER) at 52°C temperature was 1.67 (kg water/kWh). Moreover, the hypothetical outcomes uncovered that the Page's model was the most fitting model for evaluating and calculating the performance of mango slices.

2. CONCLUSION

- In the studies, it is finding that the drying temperature range of ISD is 52°C -60°C. The temperature of the drying chamber depends upon solar irradiation and space of a solar air heater.
- The drying rate observed is higher in forced convection solar dryer as compared to the natural convection solar dryer.
- Solar dryer efficiency is increases if incorporated the PCM with the solar dryer.
- The product quality is better in the indirect mode of the solar dryer as compare to other type of drying method.
- The moisture loss and drying time of the product are mainly depending upon the mass flow rate of hot air.
- For decreasing the dependency on solar energy, we use dryer who is incorporate with PCM or fuel.

REFERENCES

APEDA (2016) Agricultural & Processed Food Products Export Development Authority, Ministry of Commerce & Industry, GOI," *National Programme for Organic Production (NPOP)*. [Online]. Available: http://apeda.gov.in/apedawebsite/%0A

El-sebaii AA, Shalaby SM. Solar drying of agricultural products: a review. RenewSustain Energy Rev 2012;16:37–43. https://doi.org/10.1016/j.rser.2011.07.134.

Lamidi RO, Jiang L, Pathare PB, Wang YD, Roskilly AP. Recent advances in sustainabledrying of agricultural produce: a review. Appl Energy2019;233–234:367–85. https://doi.org/10.1016/J.APENERGY.2018.10.044.

Kumar R, Rosen MA. A critical review of photovoltaic-thermal solar collectors forair heating. Appl Energy 2011;88:3603–14. https://doi.org/10.1016/j.apenergy.2011.04.044.

S. K. Shukla (2008) Evaluation of Convective Heat and Mass Transfer in Open Sun and Green House Drying. *Proc. 2008 ASME Summer Heat Transf. Conf. HT2008*, 1–5.

A. A. Ananno, M. H. Masud, P. Dabnichki, and A. Ahmed (2019) Design and numerical analysis of a hybrid geothermal PCM flat plate solar collector dryer for developing countries. *Sol. Energy*. 196: 270–286. doi: 10.1016/j.solener.2019.11.069.

A. El Khadraoui, S. Bouadila, S. Kooli, A. Farhat, and A. Guizani (2017) Thermal behavior of indirect solar dryer: Nocturnal usage of solar air collector with PCM. *Journal. Clean. Prod.* 148:37–48. doi: 10.1016/j.jclepro.2017.01.149.

V. T. Karathanos and V. G. Belessiotis (1999) Application of a thin-layer equation to drying data of fresh and semi-dried fruits. *J. Agric. Eng. Res.* 74, no. 4, pp. 355–361, , doi: 10.1006/jaer.1999.0473.

P. K. Devan, C. Bibin, I. A. Shabrin, R. Gokulnath, and D. Karthick, "Materials Today : Proceedings Solar drying of fruits – A comprehensive review," *Mater. Today Proc.*, no. xxxx, 2020, doi: 10.1016/j.matpr.2020.04.041.

O. V. Ekechukwu, "Review of solar-energy drying systems I: an overview of drying principles and theory," *Nature*, vol. 40, no. 6, pp. 593–613, 1999, doi: 10.1038/249726a0.

A. M. Castro, E. Y. Mayorga, and F. L. Moreno, "Mathematical modelling of convective drying of fruits: A review," *J. Food Engg.*, vol. 223, pp. 152–167, 2018, doi: 10.1016/j.jfoodeng.2017.12.012.

M. Planinić, D. Velić, S. Tomas, M. Bilić, and A. Bucić, "Modelling of drying and rehydration of carrots using Peleg's model," *Eur. Food Res. Technol.*, vol. 221, no. 3–4, pp. 446–451, 2005, doi: 10.1007/s00217-005-1200-x.

M. Ozdemir and Y. O. Devres, "The thin layer drying characteristics of hazelnuts during roasting," *Food Sci. Technol. Res.*, vol. 42, no. 1999, pp. 225–233, 2000.

G. N. Anwar, S.I.and Tiwari, "Evaluation of convective heat transfer coefficient in crop drying under open sun drying," *Energy Convers. Manag.*, vol. 42, pp. 627–637, 2000.

A. Midilli and H. Kucuk, "Mathematical modeling of thin layer drying of pistachio by using solar energy," *Energy Convers. Manag.*, vol. 44, no. 7, pp. 1111–1122, 2003, doi: 10.1016/S0196-8904(02)00099-7.

I. Doymaz, "Drying kinetics of black grapes treated with different solutions," *J. Food Eng.*, vol. 76, no. 2, pp. 212–217, 2006, doi: 10.1016/j.jfoodeng.2005.05.009.

M. M. Alkilani, K. Sopian, S. Mat, and M. A. Alghoul, "Output air temperature prediction in a solar air heater integrated with phase change material," *Eur. J. Sci. Res.*, vol. 27, no. 3, pp. 334–341, 2009.

A. Lamharrar, A. Idlimam, and M. Kouhila, "Thin layer forced convective solar drying characteristics of artemisia herba-alba," *J. Mater. Environ. Sci.*, vol. 6, no. 1, pp. 264–271, 2015.

A. Singh, "Experiment study of mixed mode solar drye," KNIT,sultanpur,India., 2016.

M. Kumar, P. Khatak, R. K. Sahdev, and O. Prakash, "The effect of open sun and indoor forced convection on heat transfer coefficients for the drying of papad," *J. Energy South. Africa*, vol. 22, no. 2, pp. 40–46, 2011, doi: 10.17159/2413-3051/2011/v22i2a3214.

M. A. Eltawil, M. M. Azam, and A. O. Alghannam, "Solar PV powered mixed-mode tunnel dryer for drying potato chips," *Renew. Energy*, vol. 116, pp. 594–605, 2018, doi: 10.1016/j.renene.2017.10.007.

A. Djebli, S. Hanini, O. Badaoui, B. Haddad, and A. Benhamou, "Modeling and comparative analysis of solar drying behavior of potatoes," *Renew. Energy*, vol. 145, pp. 1494–1506, 2020, doi: 10.1016/j.renene.2019.07.083.

Anderson JO, Westerlund L. Improved energy efficiency in sawmill drying system.Appl Energy 2014;113:891–901. https://doi.org/10.1016/j.apenergy.2013.08.041.

Seyfi S. Design, experimental investigation and analysis of a solar drying system.Energy Convers Manag 2013;68:227–34. https://doi.org/10.1016/j.enconman.2013.01.013.

Chandramohan VP. Numerical prediction and analysis of surface transfer coefficientson moist object during heat and mass transfer application. Heat Transfer Eng2016;37:53–63. https://doi.org/10.1080/01457632.2015.1042341Z

S. Vijayan, "Performance Study of an Indirect Forced Convection Solar Dryer for Potato," *Int. J. Appl. Eng. Res.*, vol. 10, no. 50, pp. 454–458, 2015.