International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Construction of a Solar Seed Dryer

D. Remalya[1], K. Ravi Kumar[2], B. O. Madhu[3], N. Sandeep[4]

Submitted: 10/05/2023 **Revised:** 18/07/2023 **Accepted:**10/08/2023

Abstract: - Solar thermal systems have shown to be practical, economical, and environmentally benign when used for the preservation of agricultural goods such as fruits, vegetables, coffee, and other commodities. By drying crops and food using solar heating systems, we can improve product quality, reduce waste, and use conventional fuels less often, all of which contribute to a higher standard of living. Unfortunately, many nations that may benefit greatly from solar food processing technologies do not have enough access to trustworthy information. A solar dryer for drying maize seeds is the primary subject of this research. The solar seed drier took practicality, cost, and accessibility of materials into account throughout its design process. sun seeds dryers typically include an absorber plate, a transparent cover (glass), a drying chamber, and a sun collector. Measurements of 1000 mm x 1000 mm (1 m^2) make up the solar seed drier's cross-section. The dimensions of the box's front were trimmed to a length of 1000 mm and a height of 320 mm. A 30 mm tall and 600 mm long vent was cut into the front. The solar seed drier's performance was evaluated, and it was found that in the no-load test, the heated air within the dryer was consistently hotter than the surrounding air. During the three days, a considerable quantity of moisture was removed. However, it was at its highest on day one and at its lowest on day two.

Keywords: *Solar dryer, moisture content, temperature, drying time.*

Introduction

Globally, there is an increasing recognition that renewable energy is crucial for enhancing technological access for farmers in underdeveloped nations to boost their output (Waewsak et al., 2006). Solar thermal technology is becoming recognized as an energy-efficient solution in agricultural applications. It is favored over other energy sources like wind and shale because to its abundance, inexhaustibility, and non-polluting nature (Akinola 1999; Akinola and Fapetu, 2006; Akinola et al., 2006).

Solar air heaters are uncomplicated systems that harness solar energy to heat air, used in various applications necessitating low to moderate temperatures below 80°C, including crop drying and room heating (Kurtbas and Turgut, 2006). Drying techniques are crucial for the preservation of agricultural goods. They are characterized as a process of moisture extraction resulting from concurrent heat and mass transfer (Ertekin and Yaldiz, 2004). Ikejiofor (1985) identifies two categories of water in food items: chemically bonded water and physically retained water. During the drying process, only the physically bound water is eliminated. The primary factors contributing to the appeal of dried goods are extended shelf-life, product variety, and significant volume reduction. This might be further enhanced by advancements in product quality and process applications.

The use of dryers in underdeveloped nations may diminish post-harvest losses and substantially enhance food supply in these regions. Loss estimations are often reported to be around 40%, but under really bad situations, they may reach almost 80%. A considerable proportion of these losses is attributable to inadequate and/or delayed drying of food items, including cereal grains, legumes, tubers, meat, and fish. Bassey (1989); Togrul and Pehlivan (2004).

Traditional drying, often conducted on the ground in open air, is the predominant technique used in underdeveloped nations due to its simplicity and cost-effectiveness in food preservation. Disadvantages of open air drying include: exposure of food to rain and dust; unregulated drying conditions; direct sunlight exposure, which is detrimental to some food items; bug infestations; and animal interference (Madhlopa et al., 2002). To enhance conventional drying methods, solar dryers, which may significantly mitigate the aforementioned drawbacks of open-air drying, have garnered major interest over the last two decades (Bassey, 1989). Forced convection solar dryers may be used successfully. However, they need power, which is regrettably absent in most rural regions, to function the fans. Despite the availability of energy, prospective users of the dryers are unable to afford it because of their very low income. Consequently, forced convection dryers are unlikely to be widely suitable in several poor nations. Natural convection dryers facilitate the circulation of drying air without the assistance of a fan. Consequently, they are the most relevant to rural regions in emerging nations.

[1,2,3,4]*Assistant Professor, Department Of Agricultural Engineering, International School Of Technology And Sciences For Women, A.P, India.*

Solar drying may be categorized into direct, indirect, and mixed types. In direct solar dryers, the air warmer encompasses the grains, allowing sun energy to penetrate a transparent cover and be absorbed by the grains. The heat necessary for drying is mostly supplied by radiation to the top layers, followed by conduction into the grain bed.

In indirect dryers, solar energy is harnessed in a distinct solar collector (air heater), and the warmed air subsequently traverses the grain bed. Conversely, in mixed-mode dryers, the heated air from a separate solar collector is directed through the grain bed, while concurrently, the drying cabinet absorbs solar energy directly through its transparent walls or roof. The aim of this project is to create a mixed-mode solar dryer that dries grains concurrently using direct radiation from the glass walls and roof of the cabinet, as well as warm air from the solar collector. The dryer's performance was assessed.

Literature Survey

I.O. Ohijeagbon L.I. Ogunfowora, J.I. Omale and P. Ameh (2016), Their paper elucidates the utilization of renewable energy sources, specifically solar energy, for the efficient drying of seeds and food items, which is essential for the preservation of agricultural products in developing countries with limited access to electricity. Their study examines the effects of employing a solar GPS beacon on the energy efficiency of drying processes. Three categories of drying conditions were conducted simultaneously: a conventional solar box dryer, a solar box dryer augmented by a GPS beacon, and outdoor drying over an effective total drying duration of 6 hours per day for 5 days. The average solar power for outdoor, fixed, and tracking systems was determined to be 156.54, 180.72, and 186.81, respectively.[1]

Mangesh Gavhale, Swapnil Kawale, e.l., (2015), A small-scale solar dryer for tomatoes was constructed and tested at Yola, located at 9°14′ N latitude and 12°26′ E longitude, using locally accessible materials. They built a seed drier that dries maize and beans better using a similar method. The drier was designed to preserve seeds without the laboriousness and product deterioration of sun drying. To help ranchers dry tomatoes, this solves climate issues. The solar dryer has a plate, intelligent walls, a glass rooftop, a preheating air protection plate, moisture-removal panels, and a chimney stack for circulation. Tests showed the dryer could reach 47°C in the drying chamber. The dryer temperature and drying rate outperformed open sun drying. The findings showed that solar drying outperformed open sun drying in drying rate and spoiling risk. [2].

Isaaac Ajunwa, Dangana M, Kulla Muhammed, Abdullahi D S Yawas, (2020), Their technique was based on food conservation, which is crucial. Managing and protecting crops during surpluses ensures sustainability and species preservation during shortages. Flat plate collectors (FPCs) are frequently stationary, and reflector location on them is inconsistent. This article reports on an experimental trial of a circular solar dryer with a manually driven FPC that tracks the sun. Manual operation of the FPC was essential to minimize additional expenses on the present plan. The Designing Condition Solver (EES) and TRNSYS 16 virtual products recreated the precise placements of reflectors east and west of the Flat Plate Collector (FPC) during the first quarter of the protracted research, including the test. This determined the best reflector conditions for maximal insolation. During testing, the reflectors east and west of the FPC were seen at 40° and 80° angles to the horizontal plane. We compared the solar dryer exhibition's moisture loss rate, drying rate, operating efficiency, and drying effectiveness while the FPC was stationary and when it tracked the sun. The analysis showed that the sun-tracking dryer increased moisture loss by 5.11%, drying rate by 2.10×10^-5 kg/s, thermal efficiency by 3.92%, and overall drying efficiency by 2.0% compared to stationary flat plate collectors. The backhanded solar dryer, which can physically monitor the sun on a single axis in Zaria, Nigeria, improved system performance. [3].

Suraj Pathak, Shadab Shah, Mahipal Charan, e.l., (2020), Their research developed a solar drier to overcome standard sun drying techniques' drawbacks, such as direct sunlight exposure, pollution, bird and insect interference, and inadequate monitoring. The solar dryer heats air and dries items using solar energy. The building has an air radiator or solar heater and a plate rack-equipped sun drying chamber. A blower moves heated air in a solar collector to circulate within chambers and remove moisture from the materials inside the collector and chamber. The slant point is the dryer's main efficacy boundary. Thus, we instantly discovered the protective plate's celestial tilt signal. The slant point should be below the northern hemisphere latitude. Mumbai's scope is 19.01°N, slanting 15°C. We calculated the solar dryer framework length at 116.41 cm, with an authority area of (80.4 x 40) cm², using this angle as a reference. [4]

Eze J I and Agbo K E, e.l., (2020), Their proposed ginger drying research compared natural and artificial sunlight drying efficiency. A knife was used to clean, arrange, and slice fresh ginger rhizomes. The plug skin was left intact on some, whereas the stopper skin was pulled off others. Sun-dried, stripped, and unpeeled samples were dehydrated in a solar drier and outside for a long time. Samples were physico-chemically and organoleptically analyzed before, during, and after drying. Results showed that air-dried items kept color and fragrance better than sun-dried ones. Solar dryers dried faster than outside methods. Outdoor drying lowered the total volatile compound (TVC) content of dried ginger to 66.7% for stripped ginger and 57.6% for unpeeled ginger, however sunlight-based drying reduced it to 47.6% and 9.63%. Solar-dried unpeeled ginger had a moisture content of 7.0%, which is within the worldwide market's acceptable range of 6-9%. Outdoor drying might reach 17.0% in the research location. Although no trend showed in crude protein concentration vs drying time, solar-dried ginger had lower protein levels than air-dried ginger. [5].

Amruta R. Eswara & M. Ramakrishnarao, (2012), Their study focused on solar panel light management and drying efficiency differences. Alternative energies for post-harvest food processing are possible due to population growth and high energy prices. New solar-based food processing system produces high-quality food with minimum fuel. Multiple sun dryers, gatherers, and concentrators are utilized in food processing and value improvement. SEED invented a solar-powered bureau drier with controlled airflow to dehydrate and increase value-added items made from locally farmed fruits, vegetables, greens, and forest food. A UV-reducing blue filter helps nutrients survive drying in mimicked hidden conditions. The solar seed dryer is ideal for food processing in rural locations near the harvest source because of its simple design and operation, reducing the need for costly transportation or storage of fresh items. It also defines regional business possibilities. [6].

Bala B K and Debnath N, e.l., (2012), Their planned study outlined the improvements and potential of solar drying technologies for dehydrating fruits, vegetables, herbs, medicinal plants, and fish. Trial demonstrations of several types of limited solar dryers, such as solar tunnel dryers, enhanced versions of solar tunnel dryers, roof-integrated solar dryers, and greenhouse-type solar dryers are addressed. The drying period in the solar dryers did not align with the anticipated duration for conventional sun drying, and the products exhibit high quality in terms of color and texture. Exhibitions of the solar tunnel dryer, an advanced version of the solar burrow dryer, rooftop-integrated solar dryers, and greenhouse solar dryers are shown. The correlation between the replicated and experimental outcomes is often outstanding. A multifaceted brain network technique was used to anticipate the performance of the solar tunnel dryer, and the prognosis for the dryer’s display was deemed excellent after enough preparation. [7].

Schirmer, P., Janjai, S., Esper, A., Smitabhindu, R., e.l., (2017), To test a multi-purpose solar tunnel drier, bananas were dehydrated in Thailand's humid environment. The dryer has a plastic-encased level plate collector and a drying tube. Three fans driven by a 53 W solar cell module provide heated air to the drying tunnel. Drying articles are placed in a single layer on a plastic net within the drying tunnel to absorb heat from the gatherer's warm air and sun radiation. Each batch of this drier can evaporate 300 kg of processed bananas. Seven drying tests were performed on the displayed dryer at the Illustrious Chitra Lada Activities in Bangkok in May 1995. The gatherer's drying air fluctuated between 40 and 65°C, drying the bananas in 3-5 days instead of 5-7 days for typical sun drying. Due to total protection from rain, insects, and dust, solar tunnel-dried bananas had superb taste, color, and texture. The dryer may be used in rural locations without electricity since the solar module powers the fans. Dryer payback is predicted at 3 years for private delivery. [8].

Jobin Varghese, S Rupesh, Jithu Augustine, Adithya Nair, (2021), Their work manages the presentation assessment of a functioning roundabout solar dryer incorporated with an illustrative dish gatherer to dry peanuts. Nut is a broadly accessible palatable seed in India, got from a vegetable harvest (Arachis hypogaea) which is utilized either straightforwardly in food or for separating cooking oil. The framework essentially comprises of an illustrative gatherer which is given a protector made of compressed wood with air holes and aluminium foil wrapping, and a drier comprising of four plates where the peanuts are dried. The progression of hot air through the plate is kept up with utilizing an exhaust fan situated at the highest point of the drier. The fan depletes the dampness extricated from the item to make the progression of air with next to no limitation. From the examination it is found that the illustrative dish gatherer produces a most extreme temperature of 79 °C at 12.30 PM and dries 1.5 kilograms of nut in 5 hours of a day. Consequently, hot air from the illustrative dish concentrator lessens dampness content of nut by 21% more than acquired from open sunlight based drying.[9].

Wellington Souto Ribeiro, Adriano Sant’Ana Silva e.l., (2021), They worked on the solar dryer which can decrease creation costs, energy utilization, squander and is an option for little and medium makers. The solar dryer can diminish costs and is an option for little and medium makers around the world. The utilization of new and handled tomatoes is high on the planet, however post-gather misfortunes is additionally and drying is a choice to diminish these misfortunes. The temperature upkeep and drying time compares 30% of the expenses. The goal was assessed the tomato physicochemical attributes in the wake of drying in high quality solar dryer. 'Carmen' tomato natural products were dyed in water, 2.5% NaCl arrangement, 2.5% NaCl + 0.5% $CaCl_2$ arrangement and unbleached. Tomato cuts were put in a high-quality sun powered dryer from 7:00 to 17:00. The sun powered dryer model was wood made, containing a gatherer and a drying chamber. The typical expense of the camera was US$ 13.08 (1 Brazilian Genuine = 0.26 US Dollar). Water misfortune, drying energy, numerical models and physicochemical qualities of new and dried tomatoes were assessed. The typical length of sun powered drying for the four medicines was 30 h and the Midilli and Kucuk numerical model was the most changed. The acridity, diminishing sugars and solvent solids were concentrated by drying, while ascorbic corrosive was decreased. The pH didn't change. Tomatoes 'Carmen' can be dried in a hand tailored solar dryer for 30 h while keeping up with item quality.[10]

Methodology:

Software Requirement is Arduino IDE and hardware requirements are Arduino uno, solar panels, charge controller, relay module, temperature sensor, heating element, fan, buck converter and battery

Figure 1 illustrates the block diagram of the seed drier using a solar system unit. The Arduino UNO serves as the central component of the system. This system utilizes solar panels to provide power supply. During daylight, it absorbs light energy and turns it into electrical energy. The produced energy is sent to the charge controller, which adjusts the voltage before supplying it to a battery.

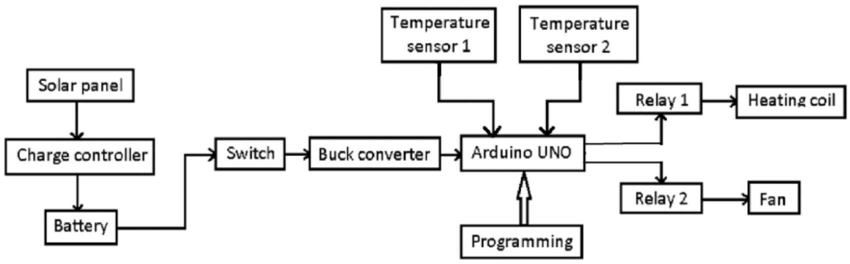

Figure 1. Block diagram of seeds dryer using solar system

The charge controller regulates the battery voltage and either diminishes or disconnects the power from the solar panel. The battery is linked to the switch for control purposes. One terminal of the switch is linked to the Buck converter. The Arduino operates on a 5V DC source, whereas the battery voltage is 12V. A Buck converter is used to decrease the voltage from 12V to 5V. Two temperature sensors are employed: one to monitor the chamber temperature and the other to measure the ambient temperature. The heating coil facilitates air heating by convection for seed drying. The fan is used to expel heated air into the chamber [3]. The fan and heating components get electricity from the battery supply, with their operation regulated by Arduino, relay1, and relay2. The temperature sensor 1 detects the current heat in the heating chamber, and the permissible temperature range for operation is specifically tailored for the exhaust fans. When the temperature exceeds the range indicated by the sensor, the fan deactivates. An Arduino will control the DC fan with a relay module. [4] The temperature sensor2 detects atmospheric temperature and is positioned next to the air tubes. During nighttime, temperature sensor 2 will activate the heating coil via relay 2. When the heating coil activates, air is sent via the air tubes to circulate above the heating coil, and the resultant hot air is propelled by a fan into the seed-containing container. The moisture contained in the grains has been expelled. These grains may now be preserved for extended periods.

Construction diagram:

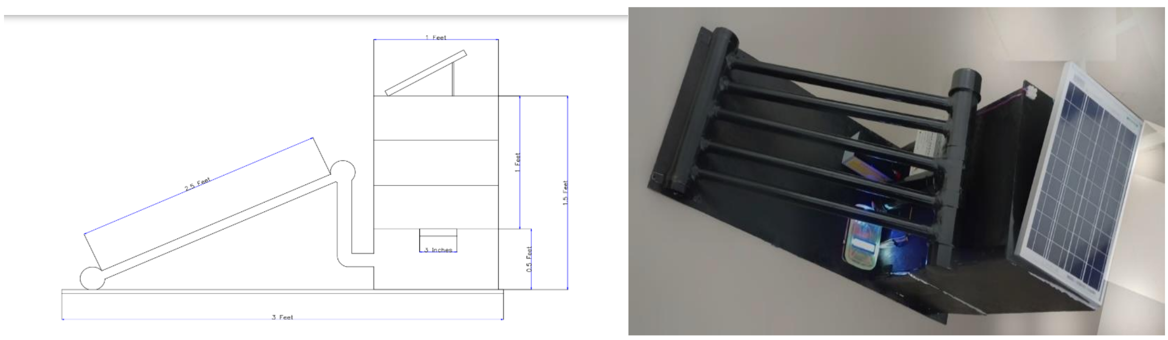

Figure 2. Constructional diagram of the solar seeds dryer system

Figure 2 illustrates the structural design of the solar-powered seed drier [5]. This is the indirect drying technique [6]. It comprises two categories of air preheating systems. The first approach utilizes atmospheric temperature to heat the air inside the air tubes. In the second way, solar radiation is used to create energy via the use of solar panels. The battery stores this electrical energy. This electrical energy is then used to generate heat in the heating element. The heated air emitted from the heating element circulates through the chamber holding grains with the assistance of an exhaust fan. Ultimately, the air will be expelled via the upper aperture of the container [7]. This system employs heat collecting tubes during sunny periods for air heating, while heating components are used at night and during overcast conditions [8].

Result and Conclusion:

The invented drying system can dry grains at certain temperatures and necessitates many days for the drying process. This technique dries 1 kilogram of peanuts within one day post-harvest. It is feasible for the peanuts to be preserved for an extended length without any alteration in color or disintegration. Upon drying the peanuts, they will not have any health hazards. It has a comparable flavor to that of peanuts dried using open sun methods. The suggested experiment demonstrates that the grains dried promptly after harvesting without any delay. In comparison to the preceding dryer systems. This approach conserves farmers' time. Working control actions and maintenance do not need expert personnel. It has excellent efficiency. It is a dependable drying method, since it dries grains both during the day and at night. This method does not need any non-renewable resources. This device is an exceptionally clean drying apparatus that does not generate any smoke or dust. This method is optimally designed for small to medium-scale farmers and agricultural holdings in distant areas. The farmer's labor is obviated since he no longer has to disseminate the grains over extensive land areas for solar drying. The drying process may be finished within a few days with this technique.

Reference:

[1] Nishanth S et al (2023) Fabrication Of Solar Seed Dryer With Auto Tracking System In Irjmets Volume:05/Issue:03

[2] Ajayi, C., Sunil, K.S., and Deepak, D. 2009. “Design of Solar Dryer with Turbo ventilator and Fireplace”. International Solar Food Processing Conference 2009.

[3] Zhonghua Dr., W., Long, W., Zhanyong, L., Mujumdar, A.S. Atomization and Drying Characteristics of Sewage Sludge inside a Helmholtz Pulse Combustor (2012) Drying Technology, 30 (10), pp. 1105-1112.

[4] Salve et al. (2016) also developed the compact and portable forced convection solar dryer for drying chilies with thermal energy storage.

[5] Kiran Kumar B M M. S, “Design and Development of Solar Powered Automatic Grain Dryer for Storage”, https://www.researchgate.net/publication/337021247

[6] M.Mohanraj, P.Chandrasekar, 2008, “Drying of Copra in a forced convection solar drier”

[7] M Deepak Borana1, Manoj J2, Nag Mohith3, Pranav K S4, “Design and Fabrication of Efficient Solar Dryer”, Volume: 07 Issue: 01 | Jan 2020, www.irjet.net

[8] Brenidorfer B, Kennedy L, Bateman C O (1995). Solar dryer; their role in post-harvest processing, Commonwealth Secretariat Marlborough house, London.

[9] A.A. El-Sebaii; S.M. Shalaby (2012): Solar drying of agricultural products: A review, Renewable and Sustainable Energy Reviews 16, 37-43.

[10] Fadhel; S. Kooli; A. Farhat; A. Bellghith (2005): Study of the solar drying of grapes by three different processes, Desalination 185, 535-541.

[11] B.K. Bala; M.R.A. Mondol; B.K. Biswas; B.L. Das Chowdury; S. Janjai (2003): Solar drying of pineapple using solar tunnel drier, Renewable Energy 28, 183-190.

[12] Wang, Y., Zhang, M., Mujumdar, A.S., Mothibe, K.J., RoknulAzam, S.M. Effect of blanching on microwave freeze drying of stem lettuce cubes in a circular conduit drying chamber, (2012) Journal of Food Engineering, 113 (2), pp. 177-185.

[13] Olaleye D.O., The Design and Construction of a Solar Incubator, 2008, Project Report, submitted to Department of Mechanical Engineering, University of Agriculture, and Abeokuta.

[14] Abhay Bhanudas Lingayata , V.P. Chandramohana,∗ , V.R.K. Rajua , Venkatesh Medab, “ A review on indirect type solar dryers for agricultural crops – Dryer setup, its performance, energy storage and important highlights”, Applied Energy, 258 (2020) 114005, https://doi.org/10.1016/j.apenergy.2019.114005

[15] W.Senadeera, I.S. Kalugalage, “Performance Evaluation of an affordable solar dryer for drying of crops”

[16] ELkhadraoui A, Kooli S, Hamdi I, Farhat A. Experimental investigation and economic evaluation of a new mixed-mode solar greenhouse dryer for drying of red pepper and grape. Renew Energy 2015;77:1–8. https://doi.org/10.1016/j.renene.2014.11.090.