Journal of Harbin Engineering University
ISSN: 1006-7043
Vol 45 No. 3
March 2024

Optimizing Drying Conditions for IVY Gourd Assessing Mixed-Mode Solar Dryer Performance in Active Versus Passive Operation

Karthikeyan R.[1], Dinesh B.[1], Dhanesh K.[1] , Bothiraajan P. M.[1]
[1]Department of Mechanical Engineering, Kongu Engineering College, Perundurai, Erode, TamilNadu, India

Abstract

The purpose of this research is to determine the best way to dry ivy gourd (Coccinia grandis) using a mixed-mode solar drier and to evaluate its efficiency in active and passive modes of operation. Effective drying techniques are required to extend the shelf life and maintain nutritional value of ivy gourd, a vegetable with a high perishability. Because it uses a combination of active and passive heating methods, the mixed-mode solar dryer can adapt to a wide range of climates. This study sounds fascinating! By investigating the drying parameters of Ivy Gourd and evaluating the performance of a Mixed Mode Solar Dryer, the researchers are addressing crucial aspects of post-harvest handling and preservation of agricultural produce. Understanding how factors like temperature, relative humidity, and air velocity impact drying time and product quality can lead to significant improvements in the efficiency and effectiveness of drying processes. Temperature, airflow rate, and drying duration were some of the variables tested in this study's drying trials. Product quality parameters such as colour, texture, and rehydration capability were used to assess the dryer's performance, in addition to drying kinetics and drying efficiency. We learned more about the relative merits of active and passive modes of operation in relation to drying uniformity and energy usage via this comparison. In active mode, the results show that the mixed-mode solar dryer performs better than in passive mode, with quicker drying rates and greater efficiency. We also found the best drying conditions to get the desired quality with the least amount of energy. The drying removal rate has finally reached 25%, and the efficiency has been achieved at 73.9%.

Keywords: Active Operation Mode, Drying Kinetics, Ivy Gourd, Mixed-Mode Solar Dryer, Passive Operation Mode.

1. Introduction

The tropical ivy gourd, scientifically known as Coccinia grandis, is an excellent source of fibre, vitamins, and minerals [1]. To prolong its shelf life and keep its nutritional value, sophisticated preservation procedures are required, nevertheless, because of how quickly it deteriorates after harvest. With its many benefits, including low cost, energy efficiency, and environmental friendliness, solar drying is quickly becoming a go-to method for preserving agricultural products that might otherwise spoil. Recent years have seen a rise in the popularity of mixed-mode solar dryers. These dryers combine active and passive heating methods, making them more adaptable and efficient in a wide range of climates [2-4]. A mixed-mode dryer is able to increase drying rates, save processing time, and maintain product quality by combining solar radiation with auxiliary heating sources [5-7]. Maximizing efficiency while minimizing energy usage requires, however, optimizing drying conditions and evaluating performance in various operating modes. Improving the drying conditions for Ivy Gourd using a mixed-mode solar drier and comparing its effectiveness in active and passive modes is the main subject of this research [8-10]. Drying kinetics and product quality can be studied by systematically experimenting with different factors such drying time, airflow rate, and temperature [11-13]. Furthermore, the efficacy and efficiency of each heating method can be better understood by comparing active and passive modes [14-15].

Sustainable drying solutions for agricultural goods, especially in areas with plentiful solar resources, might be advanced by the results of this study [16-18]. The objective of this study is to improve the effectiveness and efficiency of mixed-mode solar dryers for preserving ivy gourds by determining the best conditions for drying and testing the dryers in various modes of operation [19-21]. This will help agricultural communities maintain food security and economic sustainability [22-23].

2. Background study

Arifin MA, et al. [1] a hybrid drying technique was proposed as a consequence of this study. The effectiveness of the proposed approach was examined by testing two types of beans: coffee and chocolate. In addition, the proposed method was compared to forced convection and natural drying processes. All three performance measures were significantly improved by the proposed method, according to the test findings. The temperatures achieved were the highest of the other methods, averaging 54.68 °C for coffee beans and 54.55 °C for cocoa beans. Dehydration of coffee beans can be achieved to a depth of 27.38% and of cocoa beans to a depth of 42.67%.

Chokphoemphun, S., et al. [3] The objectives of this research were to examine the drying behaviour and drying characteristics of potato slices using a multi-stage force convection device. Over the course of the 240-minute treatment, the impacts of air velocity, hot air temperature, and potato slice location were shown experimentally. When dried in hotter, faster-moving air, the potato slices lost less moisture in the end, according to the results. Trays placed closer to the hot air input were more affected by the drying behaviour of the hot air. Each case study's experimental data was used to compare the drying behaviour to the drying model.

Elangovan E, Natarajan SK [5] By pre-treating ivy gourd samples with dipping solutions, the author want to examine the effects of sun drying on different methods. The findings demonstrate the efficacy of the proposed pre-treatment when compared to the control sample. Low activation energy and a high moisture diffusivity were two characteristics that distinguish the samples under investigation.

Jagdale, et al. [7] The sprouting, survival, and future development of the cuttings were significantly affected by the kind of cuttings and plant growth regulators. When it comes to responding to changes in shoot development environment, basal cuttings outperform all other forms of cuttings. In a controlled setting, the most promising concentration of IBA for producing tiny gourd shoots from basal cuttings was 250 ppm. All shoot parameters were greatly enhanced after submerging tiny gourd basal cuttings in 250 ppm of IBA, according to the interaction analysis.

Kandi, et al. [9] Extracts from A. vera, Bryophyllum, and ivy gourd leaves that contain insulin should be studied pharmacologically. Researchers were interested in the medicinal and pharmacological properties of the active components found in these plants. Some of these components include polyphones, terrenes, alkaloids, glycosides, and spooning. Due to their edible nature, they provide a novel dietary alternative for the control of diabetes and its long-term effects.

Mugi, et al. [11] A case containing a thermal energy storage (TES) device was compared to another case that did not, in this study. The former example used an indirect forced convection sun dryer (IFCSD). The object in question was crafted of sliced muskmelons. After analysing the drying qualities and performance measures in both instances, the following conclusions were drawn: As compared to case-B, case-A had an average collector efficiency (ηSAC) of 66.37%. There was no impact from the ηSAC on the TES device since it was put in the drying cabinet. The reason case B had a 48.90% higher average ηdr than case A was because in instance B, drying took place all day and was completed in one day, whereas case A required two consecutive days for drying.

Öztürk, et al. [13] A new double-pass solar dryer was created and evaluated in this research. For the absorbers' surfaces, the author used both standard black paint and paint with grapheme nanoparticles. In order to dry the carrot slices using hot air, a solar collector was embedded within the aluminium duct. Each system's overall energy and energy efficiency were evaluated using a variety of performance indicators. The performance of one of the systems was significantly enhanced with the addition of nonmaterial's.

Trivedi CH, et al. [19] these authors research found that ivy gourds' physical and chemical properties changed less rapidly when coated with an exogenous manifold-sorbitol. A barrier physically separates the fruit from its surroundings. When applied to ivy gourds, manifold-sorbitol significantly lowers weight, pH, and severe acidity. Conversely, pectatelyase activity, total soluble sugar, phenol concentration, and phosphomolybdate activity were all elevated. Several physiological properties of the fruit, including their texture, were positively affected by this process. Research shows that coating ivy gourds with many types of sorbitol slows down biological responses, which postpones ripening.

3. Materials and methods

For the purpose of optimizing the drying conditions for Ivy Gourd using a mixed-mode solar dryer and evaluating its effectiveness in both active and passive operating modes, this section details the experimental setup and techniques that were used. A thorough description of the experimental technique, including drying settings and data collecting methods, follows the materials used, which include the Ivy Gourd samples, the mixed-mode solar drier, and any ancillary equipment.

3.1 Solar Dryer

Dehydration of a wide range of agricultural, fruit, vegetable, herb, and even certain industrial materials can be accomplished with relative ease and little impact on the environment by use of a solar drier. It uses solar energy to speed up the drying process, which in turn lowers the materials' moisture content. Solar dryers use the sun's rays to heat air, which draws moisture out of items. The drying process usually involves a solar collector or panel, a mechanism to circulate air, and drying racks or trays. In areas where sunshine is plentiful, this environmentally friendly technique helps preserve food for longer, reduces post-harvest losses, saves energy, and boosts economic stability and food security. It mostly falls into three categories.

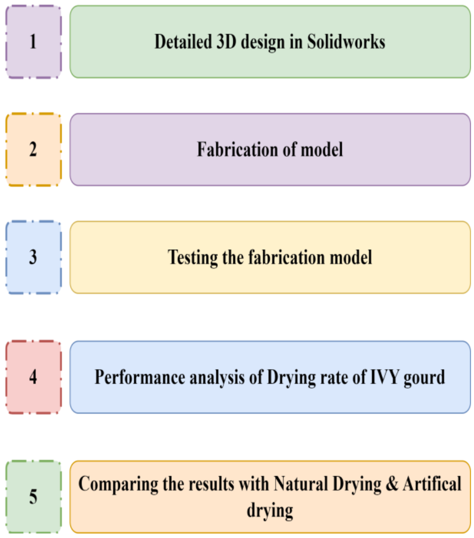

Figure 1: Overall methodology architecture

3.2 Materials

3.2.1 Metal Frame

Typical metal frame materials include machining-friendly mild steel bars, which are ideal for parts with low stress levels, including studs, bolts, gears, and shafts. Hot rolled rounds, squares, and flats are among the shapes offered, and they facilitate replacement of worn or broken components like nuts, bolts, washers, and the like. Nothing has been added to enhance the mechanical or machining properties. Cold processed (drawn or rolled) to size, scale-free bright drawn mild steel has superior grade. The dimensions are precisely controlled throughout production. Straightness and flatness are better than dark steel. It is more effective for repeated precision machining. Bright drawn steel is harder and more uniformly strong under tension. Bright steel can also be supplied in precision ground or turned forms upon request.

Figure 2: Metal Frame

3.2.2 SOLAR CABINATE

Compact and self-contained, solar cabinets feature solar panels, batteries, and components for managing electricity. An environmentally conscious and long-term power source for areas cut off from the main grid, it can collect and store solar energy for use in a variety of ways, including power generation, heating, and cooling.

Figure 3: Solar Cabinate

3.2.3 Solar Air Collector

Solar air collectors are devices that use solar energy to heat air, and they can be used in homes, businesses, and even factories. Capturing solar energy and transferring it to air moving through the collector is done by use of a flat panel or a network of tubes that contain absorber material. Space heating, ventilation, or drying can all benefit from this heated air, which helps to reduce energy consumption and promotes sustainability. One way to utilize solar energy for heating air is using a solar air collector. Insulation, an absorber plate, and a see-through cover are the usual components. The absorber plate transforms solar energy into heat when light enters the system via the see-through cover. A duct or channel is used to transport the thermal energy from the collector's hot air to another area or system. An eco-friendly and economical substitute for traditional heating systems, solar air collectors find widespread use in heating applications throughout residential, commercial, and industrial sectors.

Figure 4: Solar Air Collector

3.2.4 Air Blower

A mechanical device that can generate a gaseous or airstream at high velocity is known as an air blower. Ventilation, cooling, drying, and air movement are some of its usual uses in commercial, residential, and industrial environments. Air blowers are available in a variety of sizes and styles to meet the needs of various tasks. The mechanical device known as an air blower can be used to create a regulated flow of gas or air. In most cases, it's powered by an engine or electric motor and has an impeller (or fan) that turns to generate airflow. Ventilation, heating, ventilation, and air conditioning systems, pneumatic conveying, and industrial operations are just a few of the many uses for air blowers. Their primary function is to transfer gas or air from one place to another, where it can be cooled, dried, or pressurised as needed. From little, handheld models ideal for home use to massive, industrial-grade blowers designed for demanding tasks, there is an air blower out there to meet every purpose.

Figure 5: Air Blower

3.2.5 Stainless Steel Sheet

Flat, thin, and long-lasting, stainless-steel sheets are made of iron and at least 10.5% chromium, the latter of which makes the former resistant to corrosion. Its durability, resistance to corrosion, and good looks make it useful in many fields, including building, manufacturing, and home appliances. Flat and thin metal plates constructed of the corrosion-resistant alloy stainless steel—which mostly consists of iron, chromium, and other elements like nickel and molybdenum—are called stainless steel sheets. The exceptional resistance to rust, corrosion, and discoloration of stainless-steel sheets makes them perfect for areas where cleanliness and longevity are paramount. Stainless steel sheets find widespread usage across several industries and applications. A variety of grades and coatings are available for these sheets, making them suitable for a wide range of applications in building, automobile manufacture, kitchen appliances, ornamental purposes, and industrial equipment, among others.

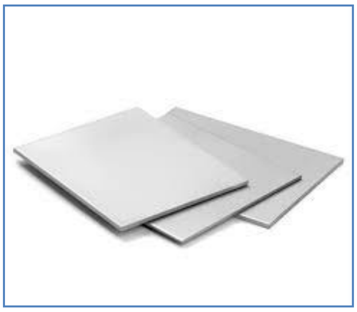

Figure 6: Stainless Steel Sheet

3.2.6 Glass

The clear cover or panel, usually constructed of tempered glass or plastic, is what we term a "glass component" in solar dryers. Its placement on top of the dryer creates a greenhouse effect by letting sunlight in while trapping heat. By using solar energy, this aids in the effective drying of foodstuffs and other things.

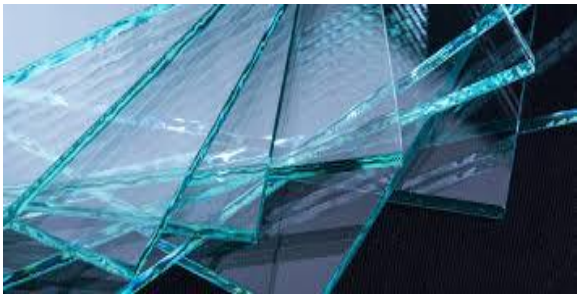

Figure 7: Glass

3.2.7 Aluminium Sheet

To improve the effectiveness of sun drying systems, a thin, flat piece of aluminium material called an aluminium sheet is used. It helps focus and absorb solar energy, which speeds up the drying process of food and other materials when placed as a reflector or absorber within the dryer.

Figure 8: Aluminum Sheet

3.2.8 Galvanized Wire Mesh

A solar dryer's galvanised wire mesh is a kind of corrosion-resistant steel wire mesh that has been treated with zinc. The solar dryer uses it as a drying surface to efficiently and effectively dry a variety of products by using solar energy.

Figure 9: Galvanized Wire Mesh

3.2.9 Temperature Sensor

One component of a solar dryer that detects and keeps tabs on the dryer's inside temperature is the temperature sensor. It prevents sun drying from being too hot or too cold by controlling the temperature, which in turn increases energy efficiency.

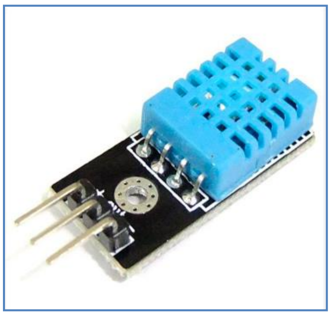

Figure 10: Temperature Sensor

3.2.10 Pu Hot Air Hose

When talking about solar dryers, the term "PU hot air hose" describes the polyurethane (PU) hose used to transfer the hot air that is produced by the sun during the drying process. It improves the solar dryer's performance for a number of uses by effectively directing hot air from the collectors to the drying chamber.

Figure 11: Pu Hot Air Hose

3.2.11 Digital Anemometer

One component of a solar dryer is a digital anemometer, which electrically measures the wind speed and direction. It helps the solar dryer achieve optimal airflow, which guarantees that agricultural goods are dried efficiently. Insights like this improve sun drying efficiency and product quality by allowing for more precise control over the drying process.

Figure 12: Digital Anemometer

3.2.12 SOLAR POWER METER

A solar dryer's solar power metre tracks the amount and efficiency of the sun's rays as they dry the material. To better manage drying operations and energy consumption, it measures the quantity of solar energy that the dryer absorbs and turns into heat.

Figure 13: solar power meter

3.2.13 Hygrometer

To monitor and regulate the relative humidity of the air inside the drying chamber, a hygrometer is a crucial component of any solar dryer. By assisting in the maintenance of the correct humidity levels, it guarantees ideal drying conditions, enabling the efficient and effective dehydration of food or other materials by solar power.

Figure 14: Hygrometer

Active mode

1. Drying Rate: How quickly the Ivy Gourd reaches the desired moisture content.
2. Energy Consumption: The amount of energy (in this case, solar energy) required to achieve the drying process.
3. Uniformity of Drying: Ensuring that all parts of the Ivy Gourd dry evenly to maintain quality.
4. Operating Costs: Including maintenance and initial setup costs associated with the solar collector.

Passive mode

1. Drying Time: How long it takes for the Ivy Gourd to dry compared to the active mode.
2. Energy Efficiency: Although passive drying doesn't require additional energy input, the overall efficiency can be evaluated based on how effectively solar radiation is utilized.
3. Product Quality: Assessing whether passive drying maintains the desired quality of Ivy Gourd compared to active drying.
4. Cost-effectiveness: Considering the initial setup and maintenance costs associated with passive drying compared to its benefits.

Solar drying systems that combine forced convection with direct sun radiation are known as mixed-mode solar dryers, and they are quite effective for drying agricultural goods. If you're looking for a sustainable and efficient method to dry ivy gourd and other fruits and vegetables, this might be it. In general, this is how it goes down:

i Solar Collector: A solar collector, sometimes a concentrator or a flat-plate collector, is the main component of a mixed-mode solar dryer. Its job is to soak up sunlight and turn it into heat. A basic flat surface or a complex system with reflectors can serve as this collector, concentrating sunlight.

ii Air Circulation: A mixed-mode solar dryer cannot function without an air circulation system. The technology that transports air through the collector might be either a fan or a natural convection system.

iii Drying Chamber: When the ivy gourd is ready to be dried, it is put in the drying chamber. It has ducts that go to the solar collector. To make sure the ivy gourd dries evenly, this room might include several racks or trays for arranging it in a single layer.

iv Temperature and Humidity Control: The mixed-mode solar dryer can have humidity and temperature controls to make sure everything dries perfectly. A drying chamber's ventilation and temperature controls might be as basic as a set of vents.

v Monitoring and Control System: To keep tabs on drying factors like temperature and humidity, certain high-tech mixed-mode solar dryers come with built-in sensors and a control system. For the best drying results, these systems can regulate the airflow and temperature on their own.

Here's how the drying process works:

i. **Solar Energy Absorption:** Heat is produced when the solar collector takes in light from the sun. To make the drying chamber hotter, this heat is used.

ii. **Forced Convection:** The air circulation system transfers the warm air from the solar collector to the drying chamber using a fan or natural convection. The ivy gourds, set on trays, are dried out as the hot air blows over them, soaking up any moisture.

iii. **Optimal Drying Conditions:** If there is a control system, it keeps an eye on the humidity and temperature to make sure the drying conditions are just right. To get the dried ivy gourd to the right moisture content, it changes the airflow and temperature.

iv. **End of Drying:** The ivy gourd is taken out of the drier after it gets the moisture level that is needed.

v. **Moisture Removal:** As the warm air circulates through the drying chamber, it picks up moisture from the ivy gourd. This moisture-laden air is then vented outside the system.

Energy efficiency, less reliance on fossil fuels, and preservation of the nutritional content of dried items are only a few of the benefits offered by mixed-mode solar dryers. In sunny regions, when other drying techniques don't work as well, they come in handy. To evaluate the efficiency of a mixed-mode solar drier, keep track of important data such as the ivy gourd's dried quality, drying time, humidity, and temperature.

3.3 Moisture Content Removal

Percentage of moisture content removal is calculated using the equation 1:

$M_w = \frac{M_i - M_f}{M_i} \times 100$------(1)

$M_w = 25\%$

Where,

M_w -Moisture Content Removal in one day

M_i - Initial Mass

M_f- Final Mass

3.4 Dryer Efficiency (%):

Dryer efficiency can be calculated using the equation 2:

$\eta dryer = \frac{M_w h_{fg}}{IA + P_{blower}}$------ (2)

$\eta dryer = 73.9\%$

Where,

M_w – Moisture Content

h_{fg} – Latent Heat

I – Solar Intensity

A – Area of Dryer

P_{blower} –Power consumed by blower

3.5 Useful Heat Input (W):

Useful heat input for the dryer can be calculated using the equation 3:

$Q_{ic} = IA_c$------(3)

Q_{ic} = 123.12W

Where,

Q_{ic} - Heat Input

I - Intensity of Solar Radiation (W/m^2)

A_c – Dryer Area (0.125m^2)

3.6 Shrinkage Ratio (SR):

Shrinkage ratio can be calculated by using the equation 4:

$SR = \frac{W_T}{W_O}$------(4)

$SR = 0.56$

Where,

W_T – Mass of humidified product

W_O – Mass of Dehumidified product

3.7 Rate of Heat Transfer:

Rate of heat transfer can be calculated by using the equation 5:

$Q_{air} = m_a * c_p * (T_o - T_i)$ ------(5)

Q_{air} = 5.92 kJ/kWh

Where,

M_a – Mass of IVY Gourd

C_P – Specific Heat of air

T_o – Temperature Outlet

T_i – Temperature Inlet

3.8 Specific Energy Consumption (SEC):

Specific energy consumption can be calculated by using the equation 6:

$SEC = \frac{E_{in}}{m_W}$ ------(6)

SEC = 0.243 J/Kg

Where,

E_{in} – Energy Input

M_W – Mass of humidified Product.

4. Results and discussion

Results from trials evaluating the efficacy of a mixed-mode solar drier in active and passive modes of operation for the optimal drying of ivy gourd are presented in this section. In order to comprehend how various drying parameters, impact drying kinetics, energy consumption, and product quality, the findings are examined and discussed. In order to assess how well each heating mechanism accomplishes the intended drying results, we also compare active and passive modes.

Figure 15: Solar Dryer

Solar Dryer is seen in Figures 15 and 16. Various industrial processes, including manufacturing, production, and processing, need a complicated environment known as an experimental setup. The usual components include procedures, infrastructure, machinery, and equipment all functioning in tandem to accomplish predetermined production objectives.

Figure 16: Drying Chamber

Instruments used in manufacturing Because they allow for the measurement and monitoring of a wide range of physical properties and environmental variables, sensors are indispensable in industrial settings. They provide useful information for optimizing processes, ensuring quality, keeping an eye on safety, and running operations more efficiently.

Figure 17: Before Drying

Figure 18: After Drying

The first day of drying, seen in Figure 17 and last day of drying, seen in Figure 18, was done in the open sun. Ivy gourds lose an average of 1 kilogramme before sun drying, and 526 grams after just three days in the sun.

4.1 Variation of Temperature and Time

Graphing the relationship between time and air temperature over the course of five days is shown in figure 19. Due to the strong sun intensity on those days, the temperatures peak at 35.4 °C on day 1 and 35 °C on day 5.

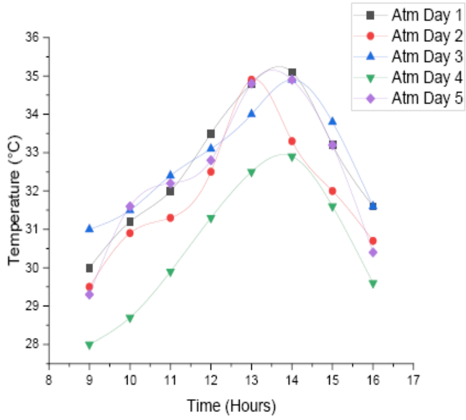

Figure 19: Time (vs) Temperature

4.2 Variation of Relative Humidity and Time

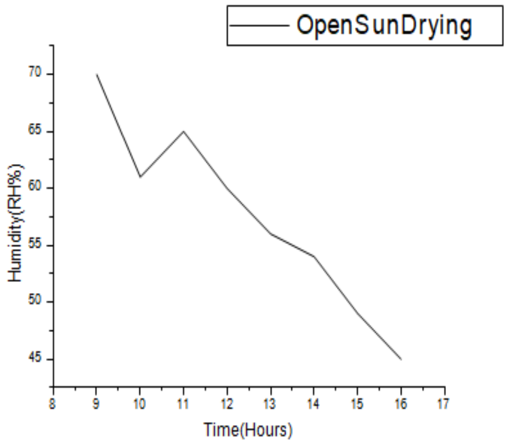

Figure 20: Time (vs) Relative Humidity (RH%)

The figure 20 shows the relation between time and relative humidity percentage. The relative humidity drastically reduces with time because the moisture content of air reduces with respect to temperature.

4.3 Moisture Content Removal

The below figures 21 and 22 show the weight reduction of Ivy gourd while drying for the 5 constitutive days. In mixed mode, the solar dryer's moisture content removal rate is high compared with open sun drying. In mixed mode, the solar dryer it reduces up to 459grams at the end of 5 days of drying, while in open sun drying it reduces only 526grams.

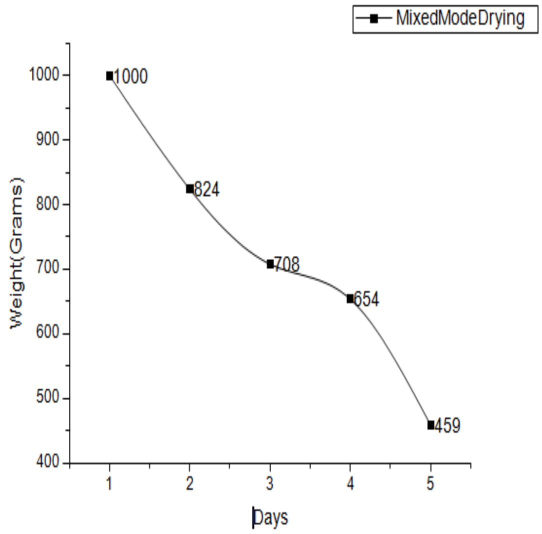

Figure 21: Days (vs) Weight Reduction Mixed Mode Drying

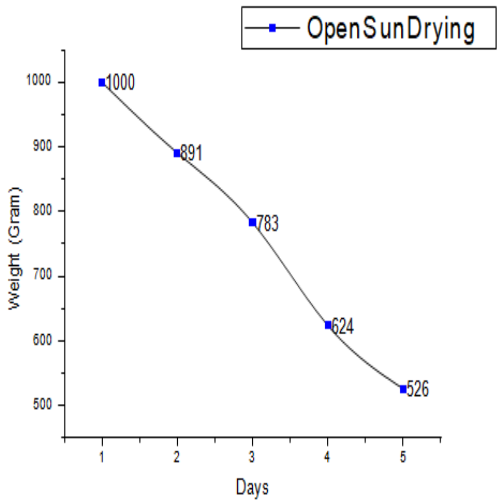

Figure 22: Days (vs) Weight Reduction

4.4 Variation of Solar Intensity and Time

The below figure 23 shows the relation of time and solar intensity, which is of 5 consecutive days. The solar intensity is high on day 1 and day 2 with 910 (W/m^2) and 907 (W/m^2) respectively.

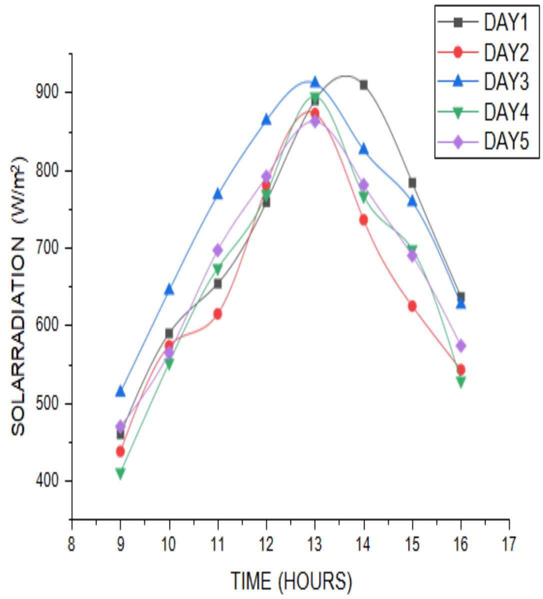

Figure 23: Time (vs) Solar Intensity

4.5 Variation of Temperature of Dryer

Figure 24 below displays the time-temperature relationship for the inlet, outflow, and tray temperatures, respectively. At midday, the intake temperature is high because the sun is quite intense.

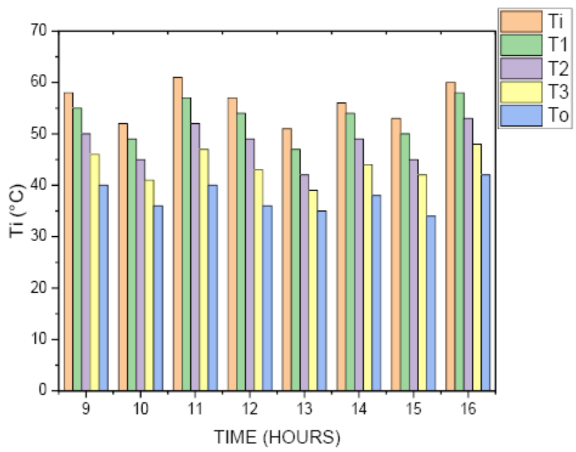

Figure 24: Time (vs) Dryer Temperature

4.6 Dryer Efficiency

The below figure 25 and 26 shows the relation figure between days and dryer efficiency and shrinkage ratio. The efficiency is calculated using equation 8.5. On day 2, the efficiency was high at 73.9%.

Figure 25: Days(vs) Dryer efficiency

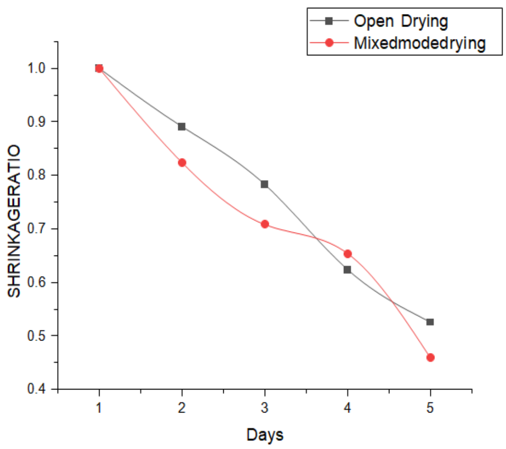

Figure 26: Days(vs) Shrinkage ratio

5. Conclusion

By exploring the world of mixed-mode solar dryers for Ivy gourd drying, this research sheds light on the wider relevance of sustainable agriculture technologies as well as their practical effectiveness. An in-depth story of resiliency, creativity, and social influence lurks beyond the superficial findings of efficacy and efficiency. Fundamentally, this study highlights the revolutionary potential of using renewable energy for agricultural processing, especially in areas without easy access to conventional drying techniques. We find out a lot of information that isn't only technical by looking at the differences between active and passive modes and optimizing the drying settings. In spite of our high hopes, we must face the facts of implementation obstacles, such as limited resources, the need for constant upkeep, and the complexities of transferring technology to areas with limited access. We are compelled to further explore the interface of technology, economics, and social dynamics in light of these problems, which serve as powerful reminders of the job that awaits us. The findings of this research do not mark the end of the road; rather, they provide a jumping-off point for further investigation and subsequent action. The study concludes that mixed-mode solar dryers are an effective and efficient method for drying Ivy Gourd. The optimization of drying parameters and the comparison of active and passive modes of drying provide valuable insights into the benefits of using mixed-mode solar dryers. The findings have important implications for the food industry and small-scale farmers. Fundamentally, this study's profound conclusion goes beyond what can be achieved in a controlled environment. The drying removal rate has finally reached 25%, and the efficiency has been achieved at 73.9%. For Further to improve the dryer percentage and efficiency using advanced methods.

Reference

1. Arifin MA, Pangaribuan P, Pramudita BA, Megantoro P. Controlling temperature using proportional integral and derivative control algorithm for hybrid forced convection solar dryer. International Journal of Electrical and Computer Engineering (IJECE). 2024 Feb;14(1):239-47.
2. Chandramoorthy, H. C. K. (2023). Coccinia Indica Leaf Extract Inhibits Herpes Simplex 2 Viruses' Propagation In vitro. King Khalid University Journal of Health Sciences, 8(1), 52-56.
3. Chokphoemphun, S., Hongkong, S. and Chokphoemphun, S., 2023. Evaluation of drying behavior and characteristics of potato slices in multi–stage convective cabinet dryer: Application of artificial neural network. Information Processing in Agriculture.
4. Chumwangwapee N, Suksri A, Wongwuttanasatian T. Investigation of bi-colour natural dyes potential for dye sensitized solar cell. Energy Reports. 2023 Oct 1;9:415-21.

5. Elangovan E, Natarajan SK. Study of activation energy and moisture diffusivity of various dipping solutions of ivy gourd using solar dryer. Environmental Science and Pollution Research. 2023 Jan;30(1):996-1010.
6. Elangovan, Elavarasan, and Sendhil Kumar Natarajan. "Convective and evaporative heat transfer coefficients during drying of ivy gourd under natural and forced convection solar dryer." Environmental Science and Pollution Research 30, no. 4 (2023): 10469-10483.
7. Jagdale, Chandrakala D., P. B. Sanap, Y. R. Parulekar, S. G. Mahadik, and K. V. Malshe. "Effect of plant growth regulators and type of cuttings on propagation of little gourd (Coccinia grandis L.)." (2023).
8. Jin, Wei, Min Zhang, and Arun S. Mujumdar. "A High-Efficiency Radio-Frequency-Assisted Hot-Air Drying Method for the Production of Restructured Bitter Melon and Apple Chips." Foods 13, no. 2 (2024): 197.
9. Kandi, Sabitha, Ramesh Kollu, Venugopal Boddula, and Venkataramana Kandi. "Glucose and Insulin Activities in the Leaf Extracts of Aloe vera, Bryophyllum, and Ivy Gourd." Global Journal of Medical, Pharmaceutical, and Biomedical Update 18 (2023).
10. Kumar, K.N.R., Shafiwu, A.B. and Saravanakumar, V., 2023. Structure of Vegetables Demand in India During Covid-19 Regime-An Econometric Approach. Journal of Agricultural and Food Chemical Engineering, 3(2), pp.1-20.
11. Mugi, Vishnuvardhan Reddy, Mulatu C. Gilago, and V. P. Chandramohan. "Performance studies on indirect forced convection solar dryer without and with thermal energy storage during drying muskmelon slices." Journal of Thermal Analysis and Calorimetry (2023): 1-16.
12. Núñez-Montiel, Natalia, Jorge Cira-Ramos, Juan Carlos Corral-Huacuz, Mario Morales-Máximo, Luis Bernardo López Sosa, Carlos A. García, Arturo Aguilera-Mandujano, Cesar Ricardo Arias Navarrete, and María del Carmen Rodríguez-Magallón. "Use of design thinking in the proposal of a multi-compound solar dryer applied to processes of traditional P'urhépecha Medicine." Energy Exploration & Exploitation (2024): 01445987231221589.
13. Öztürk, Murat, Coşkun Yüksel, and Erdem Çiftçi. "Investigation of a Photovoltaic–Thermal Solar Dryer System with Double-Pass Solar Air Collectors and Absorber Surfaces Enhanced with Graphene Nanoparticles." Arabian Journal for Science and Engineering (2024): 1-19.
14. Patel, P.M., Rathod, V.P. and Patel, V.K., 2024. Development and enhancement in drying performance of a novel portable greenhouse solar dryer. Journal of Stored Products Research, 105, p.102228.
15. Seithtanabutara, V., N. Chumwangwapee, A. Suksri, and T. Wongwuttanasatian. "Potential investigation of combined natural dye pigments extracted from ivy gourd leaves, black glutinous rice and turmeric for dye-sensitised solar cell." Heliyon 9, no. 11 (2023).
16. Subramani, S., Sivakumar, D. S., Thirumalai, N. V., & George, M. L. L. (2020). Energy and exergy analysis of greenhouse drying of ivy gourd and turkey berry. Thermal Science, 24(1 Part B), 645-656.
17. Sutar, P.K., Singh, D., Wesley, C.J. and Sahu, B.L., 2023. Evaluation of Ivy Gourd (Coccinia grandis L) Genotypes under Prayagraj Agro Climatic Conditions. International Journal of Environment and Climate Change, 13(10), pp.422-427.
18. Suwanaruang, T. and Buntam, S., Ivy gourd's Chlorophyll for Human Benefit.
19. Trivedi CH, Patel M, Mehta KJ, Panigrahi J. Improvement of shelf-life quality of ivy gourd (Coccinia grandis L. Voigt) using an exogenous coating of mannitol and sorbitol. Food Chemistry Advances. 2023 Oct 1;2:100260.
20. Witharana, Vichakshi Sashenka Bamunusingha, and Chamila Jayasinghe. "Development of an Instant Herbal Porridge Cube Incorporated with Nano-Encapsulated Coccinia grandis Leaf Extract." (2023).
21. Mohammed, Ssemwanga, Nakiguli Fatumah, and Nasejje Shadia. "Drying performance and economic analysis of novel hybrid passive-mode and active-mode solar dryers for drying fruits in East Africa." Journal of Stored Products Research 88 (2020): 101634.
22. Muliatu C.Gilgao Study of drying parameters of pineapple and performance of indirect solar

dryer supported with thermal energy storage: Comparing passive and active modes. Journal of Energy Storage, Volume 61, May 2023, 106810.

23. Mani, Purusothaman, and Valarmathi Thirumalai Natesan. "Experimental investigation of drying characteristics of lima beans with passive and active mode greenhouse solar dryers." Journal of Food Process Engineering 44, no. 5 (2021): e13667.

Author biography

Karthikeyan R

Dinesh B

Dhanesh K

Bothiraajan P M

g	Grams
m^2/s	Speed
°C	Temperature
W	Watt
%	Percentage
Mw	Moisture Removal
KJ	Kilojoule's
ΔT	Temperature Rise, ºC
Q	Air Flow Rate, m3/s
η_{Solar}	Efficiency of Solar Dryer
C_p	Specific Heat Capacity of Air, J/kgºC
I_S	Solar Radiation, W/m2
A	Dryer Area, m2