

Dehydration of Food Materials using Solar Dryer with Mobile App Integration

Nagavani C¹, Deepika T², Maria Ancy Shinesha W³, Matcha Soundarya M⁴

Electronics and Communication Engineering, Kamaraj College of Engineering and Technology, Anna University, Madurai, India.

Email: nagavani156@gmail.com¹, deepikatdivya@gmail.com², shinesha1112@gmail.com³, matchasoundarya@gmail.com⁴

Abstract

This study explores the development and integration of a solar dryer system using microcontrollers-NodeMCU and Arduino UNO with a mobile application to enhance the efficiency and user experience of food drying processes. The solar dryer utilizes renewable energy from the sun to dehydrate fruits, vegetables, and other perishable items, contributing to reduced energy consumption and environmental impact. The integration with a mobile app aims to provide users with remote control and monitoring capabilities, making the drying process more convenient and user-friendly. The mobile application allows users to select the specific product to dry and monitor drying parameters such as temperature and humidity levels, providing a customizable and automated experience. The integration of a solar dryer with a mobile app not only enhances the sustainability of food preservation but also promotes efficient resource management. By leveraging the power of renewable energy and smart technology, this system aims to contribute to the global shift towards eco-friendly and technologically advanced solutions for agriculture and food processing. The proposed solar dryer represents a step forward in creating a more sustainable and user-centric approach to food preservation, aligning with the growing demand for innovative solutions in the realm of renewable energy and smart agriculture.

Keywords: Solar dryer, NodeMCU, Arduino UNO, MobileAPP, Notification, Temperature, Humidity, Agriculture.

1. Introduction

Farming is really important for India's economy. We need to make farming better and produce more, but we also have to keep our environment safe for farmers. Drying is a way to preserve food for a long period. Using renewable energy sources, such as solar energy, to dry agricultural commodities is ecologically beneficial and has a lower environmental impact. Solar dryers of several types are now in use in various tropical and subtropical regions [1]. The temperature in the solar dryer is higher than that in the sun, which lowers drying time and enhances product quality. The two common types of solar dryers are natural convection and forced convection solar dryers. Natural convection solar dryers use the natural movement of air, while forced convection solar dryers use a fan powered by electricity or sunlight. Solar thermal technology is increasingly gaining popularity as an energy-saving approach in agriculture due to its abundance, limitlessness, and lack of pollution. Even though India grows a lot of fruits and veggies, we still don't have enough for everyone because a lot of it goes bad after it's picked. This happens because we don't have enough cool trucks or places to keep them fresh after harvest [1]. To prevent waste, food is dried in a dryer, which increases shelf life by removing moisture. The sun offers a vast amount of energy to the Earth in the form of radiation, which may be used to efficiently dry food products. Traditional sun-drying, due to the improper drying process, might result in the growth of germs, insect infestations, and other potential food safety risks [2].

Drying is when we take out the extra water from grains after we pick them. Right after harvest, grains have too much moisture, around 25 to 30%. That's not good because it can make them go bad, change color, grow mold, and attract bugs. [3]. It may reduce the rice seeds germination rate. As a result, it is vital to dry grains as quickly as possible after harvesting—preferably within 24 hours [3]. Drying that is delayed or inefficient will decrease the grain quality and cause losses. Water accounts for around 85–90% of grapes. The quantity of heat taken away and moisture removed in a solar dryer is directly proportional to the velocity of warm air, relative humidity, and temperature [4]. This project builds and tests a natural convection solar dryer to reduce the amount of time required to dry various food products, such

as grapes, grains, and red chillies. The project aims to develop technology to create a solar dryer system with a mobile app and notification alerts.

2. Related Work

[1] AniketWadaskar: IOT Based Solar Hybrid Dryer discusses the design and implementation of a hybrid forced and natural convection solar dryer aimed at reducing the drying time of various food products such as grapes, tomatoes, and red chillies. The primary focus is on assisting farmers in minimizing food waste by drying grapes efficiently. The system includes a unique PCM tank design with fins for enhanced heat absorption and dissipation. Solar panels are utilized to capture solar energy, which is converted into electricity, stored in batteries, and used to power blowers and IR lights during the night. Various sensors are integrated into the system to monitor and regulate temperature, humidity, and airflow within the drying chamber.

[2] Joel I. Miano: The implementation of an IOT-based direct solar dryer system for drying Sardinella fish in the Philippines. The system utilizes technologies such as Arduino Uno, ESP-32, and a web data logger to monitor and optimize the drying process. Through thorough testing and evaluation, the system maintained the required temperature range for effective drying while keeping humidity levels in check. SMS notifications were used to alert users of any deviations in temperature during the drying process. The system incorporates a web data logger to track and analyze drying parameters, providing valuable insights for process optimization and quality control.

[3] Aditya Jain: The development of a solar-powered automatic grain dryer system designed to enhance the efficiency of post-harvest grain drying. By incorporating solar panels, Arduino Uno, sensors, conveyor belts, and heating elements, the system effectively manages moisture content, temperature, and motor speed throughout the drying process. The prototype's main goal is to streamline grain drying procedures for farmers, reducing labor requirements, and optimizing storage practices. The documented results demonstrate the successful drying of grains with varying moisture levels, confirming the system's efficacy. Emphasizing its portability, user-friendliness, and potential applicability for small- to medium-scale farming operations, the paper underscores the system's practicality and scalability.

3. Proposed Work

Figure.1 depicts the entire proposed system in form of block diagram. The solar dryer is built using the following materials: The cover of the solar drying chamber is made of glass. It allows solar radiation to enter the system but prevents heat energy from leaving the system. We paint the inside black because black absorbs almost all of the sun's heat. So, by painting it black, the chamber can soak up as much heat as possible from the sunlight. . Food items are placed on a drying tray. Square pipes are used for the construction of the dryer. These pipes are stronger and sturdier than round ones of the same weight, so they're good for building certain application. Here, we use a 27-gauge stainless steel sheet. They are often considered corrosion resistant. Stainless steel frames also resist high winds. The solar dryer's dimensions (LxBxH) are 24x24x21 inches, weighing around 10 kilograms. The heating rod will help in generating warm air. To ensure optimal performance, sensors and controllers should be installed to monitor the dryer's temperature, humidity, and airflow. The microcontroller is programmed to manage and control the overall process of the unit. LM35 sensors are used to determine the temperature inside the dryer and DHT11 sensor will monitor environmental temperature, they are connected to the Node MCU. By using the mobile app, we must select the product we have to dry. Since various products will have different temperatures to dry, we need to set the temperature conditions accordingly. The mobile app displays the current food and its temperature and it also shows environmental temperature with respected date and time. A 12V DC fan is fixed to control chamber temperature. If the temperature goes beyond the value of temperature set, fan turns on; otherwise, remains off. The notification message is sent to the farmer through the mobile app. Once the solar dryer is constructed, it is tested and validated to meet the desired performance specifications. The product to be dried will be placed inside the dryer throughout the testing procedure, and the temperature and humidity levels will be observed over time.

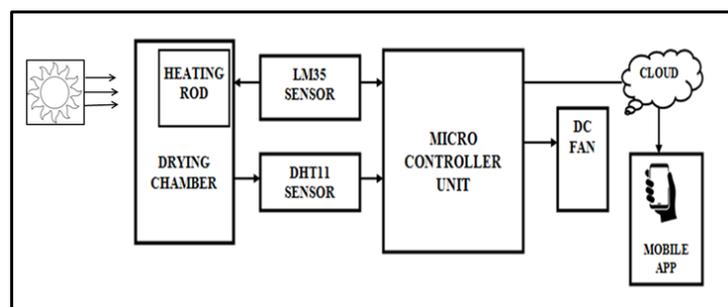


Figure 1. Functional Block Diagram

3.1 Mechanism of Solar Dryer

In a solar dryer, heat is generated automatically through the absorption of sunlight and its conversion into thermal energy. First the Solar radiation is absorbed. The absorbed sunlight is converted into thermal energy, warming up the surfaces of the solar dryer. The solar dryer is typically covered with a transparent material glass. This cover allows sunlight to enter while preventing heat from escaping, creating a greenhouse effect inside the dryer. The absorbed solar energy raises the temperature inside the solar dryer. The heated air inside the solar dryer rises due to convection, creating a natural airflow. This circulation helps in distributing the heat evenly across the drying chamber. The warm air inside the solar dryer meets the material being dried, facilitating the drying process.

3.2 Integration of Sensors and Controllers

Figure. 2, illustrates how the hardware structure was assembled. The monitoring and controlling unit with microcontroller Node MCU ESP8266 are powered by 3.3V. The Node MCU, which is based on the ESP8266 Wi-Fi module, is widely used as a controller due to its low cost, small size, and built-in Wi-Fi functionality. Arduino UNO is a popular microcontroller board that uses the ATmega328P microcontroller chip. The board contains 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power connector, and a reset button. A heating rod, also known as a heating element, is designed to produce heat when an electric current passes through it. Heating rods are typically made of materials with high electrical resistance, such as nichrome (a nickel-chromium alloy). These materials can withstand the high temperatures generated during the heating process. Install the heating rod near the drying racks where it can evenly distribute heat. The LM35 sensor in a solar dryer allows to monitor and control the temperature inside the dryer. Connect the LM35

to the analog input pin of the microcontroller. The LM35 typically requires a power supply (5V), a ground connection, and its output pin connected to the microcontroller. It can measure temperatures ranging from -55°C to $+150^{\circ}\text{C}$. The DHT11 sensor monitors external temperatures. The measuring range is 0°C to 50°C temperature and humidity 20% to 90% RH (relative humidity). A relay module is an electrical component used in solar dryers to regulate the flow of power to various components. It functions as an on-off switch that is activated by an electrical signal. By integrating the 12V DC fan with sensors, the drying system can be automated. For example, if the temperature inside the dryer exceeds a certain threshold or if humidity levels are too high, the fan can be automatically activated to bring the conditions back within the desired range. Figure. 3. Depicts the design of a solar dryer.

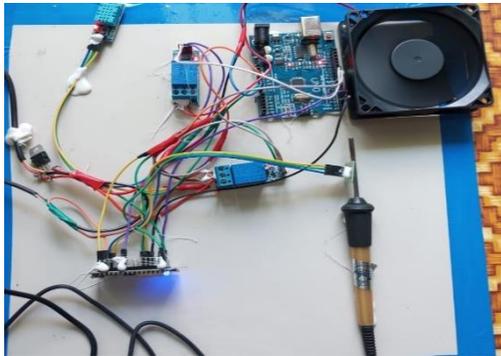


Figure 2. Hardware



Figure 3. Solar Dryer

3.3 Mobile APP

The mobile app allows users to select the product that needs to dry. Amazon Web Services (AWS) provides numerous services and tools that enable the communication and transfer of data from the cloud to a mobile app. First, the data generated or processed in the AWS cloud needs to be stored in a database or storage service. AWS allows you to create APIs (application programming interfaces) using services like Amazon API Gateway. It also provides services like the Simple Notification Service (SNS) for sending push notifications to mobile devices. Push notifications can alert the mobile app about new data, updates, or other events. Hence, by using the mobile app, the user can see the temperature inside and outside the dryer. Also, get notifications when the temperature goes high.

4. Results and Discussion

The temperature and humidity values obtained from the sensor within the dryer differ from those obtained from the outside environment. The time and temperature required to dry foods are shown in the Table I, below. An experiment with fruits such as grapes was carried out, and the moisture content was recorded. Automatic drying machines were shown to perform better in terms of drying rate than conventional approaches. The Table II, shows the recommended temperature required to dry products. Grapes may be dried in 3–4 days using an automated drying device, compared to 7 days using the usual approach. Also, chilies require 6 days of natural sunlight, but only 6 to 8 hours in a solar dryer. The Figure. 4 shows sun dried foods. The mobile app and temperature alert is shown in Figure. 5 and 6.

Table I. Temperature Inside Solar Dryer

Time	Temperature			
	Grapes	Chilies	Tulsi	Turmeric
9 am	34°C	35.5°C	32.3°C	34.2°C
10 am	35.5°C	36.6°C	34.5°C	35.8°C
11 am	37.7°C	43.2°C	43.2°C	42.7°C
12 pm	43.2°C	52.3°C	44.2°C	41.2°C
1 pm	40°C	47.3°C	46.6°C	45.2°C
2 pm	45.2°C	42.2°C	35.3°C	48.2°C
3 pm	36.8°C	36.2°C	31.4°C	43.1°C
4 pm	50°C	48.2°C	33.4°C	44.2°C
5 pm	34°C	52.2°C	42.3°C	42.1°C
6 pm	30.2°C	45.2°C	36.7°C	50.2°C

Table II. Temperature Demanded by Material

Food type	Recommended Temperature
Turmeric	35-45°C
Chilli	60-70°C
Grapes	45°C
Tulsi	40°C



Figure 4. Results Of Dried Food Items Using Dryer



Figure. 5 Monitoring of Temperature and Selection of Food

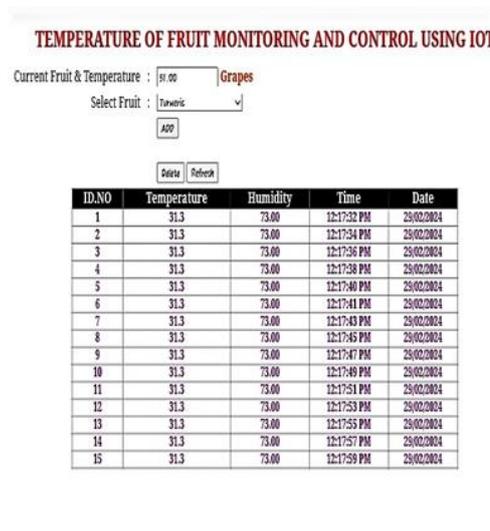


Figure 6. Status of Current Fruit and its Temperature

5. Conclusion

In conclusion, the solar dryer project represents a sustainable and efficient solution for drying various agricultural products. Through harnessing the power of solar energy, this

innovative technology not only reduces dependence on conventional energy sources but also contributes to environmental conservation. The monitoring system worked well, showing all the info needed for drying. It even sent alerts to the user, and the fan did its task. This unit is handy in remote places because it uses solar power, which is everywhere. Plus, it keeps dust away from the products, so they stay good quality. It's small, easy to set up, dries things faster than air drying, and doesn't need much upkeep because it's tough. Collaboration with local communities, governments, and non-governmental organizations can facilitate the integration of solar dryer technology into existing agricultural practices, promoting sustainable food production and economic development.

References

- [1] AniketWadaskar, Nitesh Chouriya, tejaswini Alam, Sita Yadav, VaibhavNinave and RadharamanShaha. "IOT Based Solar Hybrid Dryer". *International Journal of Advances in Engineering and Management (IJAEM)*, pp: 1680-1684, (2021).
- [2] Miano, Joel I., Michael A. Nabua, Alexander R. Gaw, Apple Rose B. Alce, Cris Argie M. Ecleo, Jewelane V. Repulle, and Jaafar J. Omar. "Optimizing Drying Efficiency Through an IoT-based Direct Solar Dryer System: Integration of Web Data Logger and SMS Notification." *International Journal of Advanced Computer Science and Applications* 14, no. 7 (2023).
- [3] Jain, Aditya, V. Balaji, R. Rohitha, and Kiran Kumar. "Design and Development of Solar Powered Automatic Grain Dryer for Storage." In *2019 IEEE International Conference on Distributed Computing, VLSI, Electrical Circuits and Robotics (DISCOVER)*, pp. 1-5. IEEE, 2019.
- [4] Patil, Pandit S., Dilip R. Pangavhane, Sanjay P. Shekhawat, Dheeraj S. Deshmukh, and M. S. Deshmukh. "Development of an iot-based solar banana dryer monitoring and control system." *International Journal of Mechanical Engineering* vol 7, issue 1, (2022). 4745-4752
- [5] Kiran, Patil, Swami Sonam, Thorat Ashwini, and Mane Pratidnya. "Solar powered automatic fruit drying system." *International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)* 5, no. 3 (2016). 1-6

- [6] Gavhale, Mangesh, Swapnil Kawale, Ramesh Nagpure, V. N. Mujbaile, and N. S. Sawarkar. "Design and development of solar seed dryer." *International Journal of Innovative Science, Engineering & Technology* 2, no. 4 (2015): 1005-1010.
- [7] Mishra, Nikita, S. K. Jain, N. Agrawal, N. K. Jain, Nikita Wadhawan, and N. L. Panwar. "Development of drying system by using internet of things for food quality monitoring and controlling." *Energy Nexus* 11 (2023): 100219.
- [8] Kumar, Ankit, Kamred Udham Singh, Mukesh Kumar Singh, Alok Kumar Singh Kushwaha, Abhishek Kumar, and Shambhu Mahato. "Design and fabrication of solar dryer system for food preservation of vegetables or fruit." *Journal of Food Quality* 2022 (2022). 1-14
- [9] Nishanth, S., Sandeep Iniyan, Sanjay Kumar, and M. Ponmurugan. "FABRICATION OF SOLAR SEED DRYER WITH AUTO TRACKING SYSTEM." *International Research Journal of Modernization in Engineering Technology and Science* 5(3),2023. 1213-1229
- [10] More, Bhagyashree, and Seema Vishwakarma. "SMART SOLAR DRYER USING IOT SYSTEM." *VSEARCH* 2021.134-139