

Smart Solar Dryer for Agriculture Purpose

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ABSTRACT

Abstract. The Smart Solar Dryer helps to dry and preserve farm products like fruits, vegetables, grains, spices and medicinal plants. Drying in the sun the old way can be a problem because it exposes the produce to dust, insects, rain and germs which can spoil it and cause losses after harvesting. The Smart Solar Dryer uses sun energy to heat and has systems to control the drying. It has a sun collector, drying room, temperature and humidity sensors, a control unit and a sun powered fan for air flow. The system checks the environment. Changes temperature and air flow automatically to dry evenly and not overheat. The data can be shown on a screen. Sent through the internet for remote checking. The Smart Solar Dryer helps farmers by reducing drying time making products better and using regular energy. It makes products longer keeps them nutritious and reduces losses after harvest. This helps farmers produce more and make money. The Smart Solar Dryer is good for the earth. Helps farmers.

Keywords: Solar, Agriculture, Dryer

1. INTRODUCTION

A Smart Solar Dryer is a system that uses sun energy and smart control to dry agricultural products like fruits, vegetables, grains, spices, herbs and medicinal plants. It is better than ways of drying in the sun because it controls the environment and makes products better.

The system has a sun collector, drying room, air flow, temperature and humidity sensors and a control unit. The sun energy is changed into heat. Sent to the drying room to remove water from the products. The smart system controls temperature, humidity and air flow to keep the drying conditions right.

The Smart Solar Dryer has advantages like protecting products from dust, insects, rain and germs making them better. It also uses regular energy and is good for the earth. By keeping products nutritious, colorful, tasty and fresh the Smart Solar Dryer helps farmers produce more and have food.

2. LITERATURE REVIEW

Solar drying is a way to preserve agricultural products and reduce losses after harvest. According to Duncan Nkolokosa Smart Solar Dryers have changed from systems to new ones with sensors, control units and smart systems. They make drying keep products good and use less manual checking.

Some studies have been done on dryers. Aditya Jain and Aftab Pasha made a powered grain dryer that removes water from grains after harvest. Dr. Drick E. Mainer wrote about ways to dry grains and how much heat is safe for them. Solar drying is simple, effective and becoming popular.

Singh and Tiwari made a convection solar dryer for grapes that uses sun energy and controls temperature and humidity. Srinivasan and Sangeetha made an Arduino-based mushroom dryer that uses temperature and humidity sensors and a fan. Sethi and Arora compared types of solar dryers and found that mixed-mode dryers are better. Fudholi et al. Studied drying and found that it works better with more sun energy.

3.MATERIALS AND METHODS

3.1 SYSTEM ARCHITECTURE

The Smart Solar Grain Dryer is a system that uses sun energy to dry grains. It has a sun panel, battery, control unit, temperature and humidity sensor, screen, relay driver, heater and fan. The sun panel changes sun energy into electricity, which is stored in the battery. The control unit controls the system. Checks the temperature and humidity.

The temperature and humidity sensor sends data to the control unit, which shows it on the screen. The relay driver helps the control unit talk to the heater and fan. The heater heats the drying room. The fan removes water and improves air flow. The control unit checks the temperature and humidity. Controls the heater and fan to keep the drying conditions right.

The user can set the operating conditions and the control unit will adjust the system. The system uses sun energy and automated checking to reduce energy use and costs. It helps preserve grain quality reduces losses after harvest and is good for the earth.

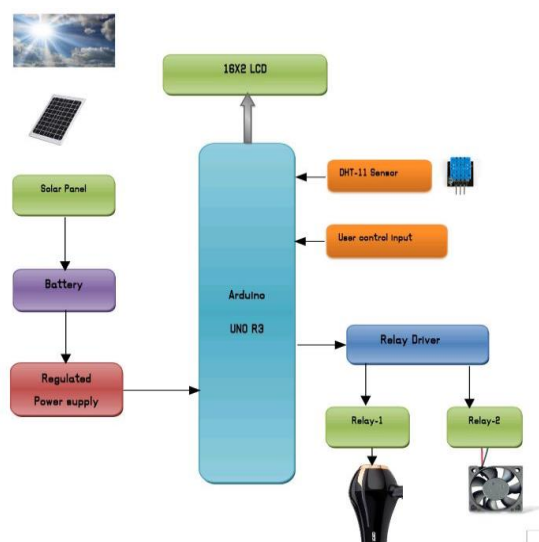


FIG 3.1.1 BLOCK DIAGRAM OF SMART SOLAR DRYER FOR AGRICULTURE PURPOSE

3.2 Hardware Components and Specifications

COMPONENTS	FUNCTION	
Solar Panel	Converts sunlight into electrical energy.	
Arduino UNO	Controls and processes data from sensors and operates the system.	
LCD	Displays temperature, humidity, and system status.	
Relay	Acts as an electronic switch to control high-power devices.	
DC fan	Circulates air inside the dryer to remove moisture.	
Battery	Stores electrical energy for backup power supply.	

DHT11 Temperature and Humidity Sensor	Measures temperature and humidity levels. Regulated Power Supply Provides stable voltage to electronic components.	
Regulated power supply	Provides stable voltage to electronic components.	

3.3 WORKING ALGORITHM

The system starts with the control unit, sensor, screen, relay driver, heater and fan. The sun panel generates electricity, which is stored in the battery. The sensor checks the temperature and humidity and the control unit shows it on the screen.

The control unit checks the temperature and humidity. Controls the heater and fan to keep the drying conditions right. The user can set the operating conditions and the control unit will adjust the system. The system continues until the grains are dry.

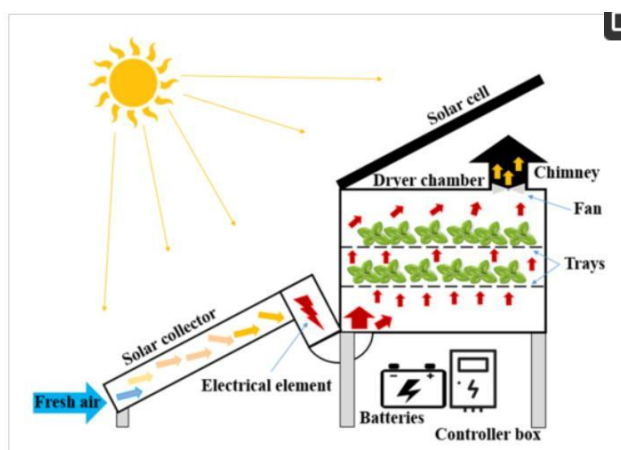


FIG 3.3.1 WORKING ALGORITHM

3.4 Experimental setup

The experimental setup has parts:

- * a solar panel
- * a battery
- * a regulated power supply
- * an Arduino UNO R3
- * a DHT11 temperature and humidity sensor
- * a 16×2 LCD display
- * a relay driver circuit
- * a heater
- * and a DC fan.

The Arduino controls the relay driver circuit.

This is based on conditions and user input settings.

The relay driver operates two relays.

Relay-1 controls the heater.

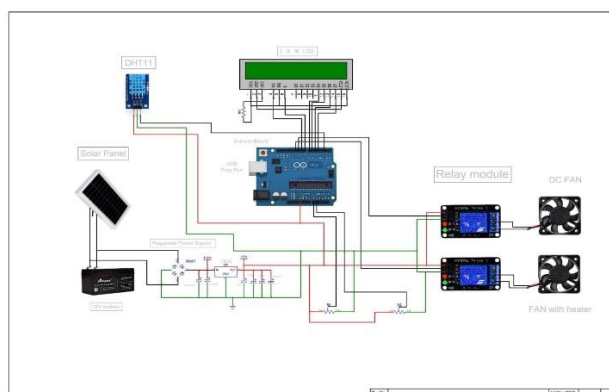
Relay-2 controls the DC fan.

When the temperature is too low for drying the heater turns ON.

When the temperature gets too high or humidity needs to be reduced the fan turns ON.

It circulates air and removes moisture from the grains.

The entire setup uses energy.
This makes the grain drying process use energy.
It is also good for the environment.
This setup is suitable for use in agriculture.
The solar panel charges the battery.
The battery supplies power, to the Arduino UNO.
The Arduino UNO controls the heater and the DC fan.
The DHT11 sensor measures temperature and humidity.
The 16×2 LCD display shows the readings.
The relay driver circuit operates the relays.
The relays control the heater and the DC fan.



4.RESULT AND DISCUSSION

The developed *Smart Solar Powered Grain Dryer* was successfully tested under different temperature and humidity conditions. The solar panel generated sufficient power to charge the battery and operate the control circuit continuously. The regulated power supply provided a stable 5 V supply to the Arduino UNO, ensuring reliable system performance.

The DHT11 sensor accurately monitored the temperature and humidity inside the drying chamber. The measured values were displayed on the 16×2 LCD in real time, allowing continuous observation of drying conditions. When the temperature dropped below the preset value, the Arduino activated the heater through Relay-1. Similarly, Relay-2 controlled the DC fan to maintain proper airflow and remove moisture from the grains.

The automatic control system maintained the desired drying environment without manual intervention. The circulation of hot air by the fan improved heat distribution and accelerated the drying process. The humidity level inside the chamber gradually decreased, indicating effective moisture removal from the grains. Compared to traditional open-sun drying, the proposed system reduced drying time and protected the grains from dust, insects, rain, and environmental contamination.

The experimental results demonstrate that the smart solar dryer is an efficient, eco-friendly, and cost-effective solution for agricultural drying applications. The integration of solar energy and automatic monitoring improves drying quality, reduces energy consumption, and minimizes post-harvest losses. Overall, the system achieved stable operation and effective grain drying performance, making it suitable for small-scale and rural agricultural applications.

4.1 Sensor Performance Analysis

The DHT11 temperature and humidity sensor was evaluated for its ability to monitor the drying chamber conditions in the smart solar grain dryer. The sensor continuously measured temperature and relative humidity and transmitted the data to the Arduino UNO for processing and control.

Temperature Measurement Performance:

The DHT11 sensor successfully detected temperature variations inside the drying chamber. As the heater was switched ON, the sensor recorded a gradual increase in temperature and provided real-time feedback to the controller. The measured temperature values enabled the Arduino to maintain the desired drying conditions by controlling the heater and fan through relays.

Humidity Measurement Performance:

The sensor effectively monitored the humidity level during the drying process. As moisture was removed from the grains, the relative humidity inside the chamber decreased. The sensor data helped the system determine when additional ventilation was required, improving drying efficiency and preventing over-drying.

Response and Stability:

The sensor showed stable performance throughout the experiment with consistent readings. It responded adequately to changes in temperature and humidity within the drying chamber, allowing automatic operation of the dryer. The displayed values on the LCD matched the expected environmental changes during the drying cycle.

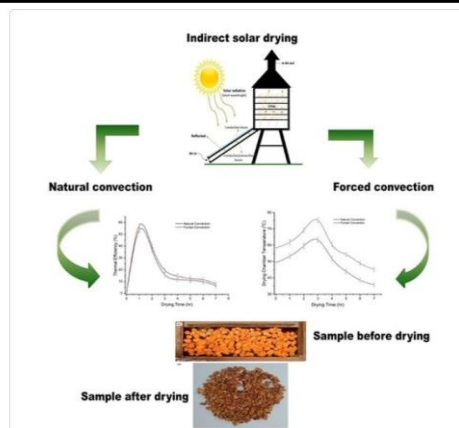
4.2 Drying Efficiency

Drying efficiency is an important parameter used to evaluate the performance of the smart solar grain dryer. It indicates how effectively the system removes moisture from agricultural products using the available solar energy and controlled drying conditions.

During the experimental testing, the dryer maintained a stable temperature and humidity level inside the drying chamber through automatic control of the heater and fan. The continuous circulation of warm air accelerated moisture evaporation from the grains, resulting in faster and more uniform drying. The reduction in grain moisture content demonstrated the effectiveness of the drying process.

The smart solar dryer achieved higher drying efficiency compared to traditional open-sun drying because it provided controlled environmental conditions and protected the grains from external disturbances such as dust, insects, and unexpected weather changes. The use of solar energy reduced dependence on conventional power sources, making the system energy-efficient and environmentally friendly.

- Factors Improving Drying Efficiency
 - Continuous monitoring of temperature and humidity using the DHT11 sensor.
 - Automatic control of heater and fan through Arduino UNO.
 - Uniform distribution of heated air inside the drying chamber.
 - Reduced moisture retention in grains.
 - Utilization of renewable solar energy.



4.4 Discussion

The developed Smart Solar Powered Grain Dryer demonstrated effective performance in drying agricultural products under controlled conditions. The integration of solar energy, temperature and humidity sensing, and automated control enhanced the overall efficiency of the drying process. The DHT11 sensor continuously monitored environmental conditions inside the drying chamber, while the Arduino UNO processed the sensor data and controlled the heater and fan through relays.

The experimental results showed that the system was able to maintain suitable drying conditions by automatically regulating temperature and airflow. The heater increased the chamber temperature when required, and the fan improved air circulation, resulting in faster moisture removal from the grains. Real-time monitoring through the LCD display allowed easy observation of system parameters.

Compared to conventional open-sun drying, the proposed system offered several advantages, including reduced drying time, improved product quality, protection from dust and insects, and less dependence on weather conditions. The use of solar energy also minimized operating costs and reduced environmental impact.

However, the system performance depends on the availability of solar radiation. During cloudy weather or low sunlight conditions, battery backup is necessary to ensure continuous operation. The accuracy of the DHT11 sensor is adequate for small-scale agricultural applications, although more precise sensors could further improve system performance.

Overall, the smart solar grain dryer proved to be a reliable, economical, and environmentally friendly solution for agricultural drying. The results indicate that the system can help reduce post-harvest losses, improve drying quality, and support sustainable farming practices.

5.CONCLUSION

In this project demonstrates how the grains after harvesting can be dried easily without any hassle and time delay. The model gave a fairly good idea of how the system can be implemented on a larger scale keeping the same idea and prospectus in mind. In addition to the time saving aspect of the farmers, it also shows how the technologically advanced controlling action, where each aspect of the grain is measured and controlled to give accurate and effective results. The proposed system is portable and handy to use and does not require any expertise on the operation as everything works automatically. The system is most suited for small and medium scale farmers who don't have the accessibility to use technologically advanced expensive dryers. The work of the farmer is eliminated as he does not have to spread the grains across huge landfills to dry them under the sun. The drying process can be completed within a few hours in this system.

Keeping the present temperature of Bangalore in mind, the output of the solar panel is good and it could achieve up to 10V, by using boost converter at the output has reached the voltage up to 30V DC with 1 amp current. The initial cost and the running cost of the proposed system is very less as all the components used are very cost effective and are readily available. The developed system can be used to dry grains such as wheat, paddy, lentils, ragi, millets, corn and coffee.

5.1 Future Scope

Being a portable prototype model this project needs to be implemented on a larger scale keeping the same aspects in mind, so that the project can be proven effective in a real world situation.

A designated area can be allotted to a village where in this larger project system is fixed and implemented, so that all the farmers can gather at a particular place and dry their grains effectively. The moisture sensor used is a simple Arduino compatible soil moisture sensor, there are few grain Moisture meters available in the market which are expensive, such grain moisture meters can be implemented in the future. To have a better heating system, a heating chamber can be designed where in heating coils are with large capacity DC fans, to dry the grains much faster.

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