PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 6 No. 1 (2025) p. 397-405
https://publisher.uthm.edu.my/periodicals/index.php/peat

A Sustainable Mi Siput Drying Machine Utilizing Solar Panel and IoT

Sharmila Sunthon[1], Muhammad Rusydi Muhammad Razif[1,*], Mohamad Haiqal Ahmad Zainaddin[1], Farzana Nazirah Ramlee[1], Yasak Abdullah[2]

[1] *Faculty of Electrical Engineering Technology, Universiti Tun Hussein Onn Malaysia,84600, Pagoh Johor,Malaysia*

[2] *Projek Perusahaan Mi Siput/Mi Sanggul Pos 13, Kg Sg ranggam,84500 Panchor,Muar,Malaysia*

*Corresponding Author: rusydi@uthm.edu.my
DOI: https://doi.org/10.30880/peat.2025.06.01.042

Article Info

Received: 21 January 2025
Accepted: 04 February 2025
Available online: 30 April 2025

Keywords

Mi siput, solar panel, drying machine, DHT22, ESP32, IoT

Abstract

Traditional drying methods for mi siput are time-consuming and inefficient, typically necessitating additional oven drying overnight. Many businesses rely on gas-powered furnaces, which pose safety issues owing to potential gas leaks. This project attempts to create a faster, safer drying system that includes wireless monitoring and control, using an ESP32 microcontroller and the Blynk app. The system includes a DHT22 sensor that measures temperature and humidity and sends real-time data to the Blynk application. Users can view changes, receive notifications, and change settings remotely. To provide optimal drying conditions, main elements include a DC fan and incandescent light bulbs. The servo motors function to regulate humidity within a specified range, resulting in effective drying. A rain sensor protects the quality of mi siput by returning the servo motor to its original position and operating the fans during rain. The system is powered by solar energy, which is transmitted via a solar panel to a charge controller and battery. The drying process worked, with the DHT22 sensor to trigger the lights and fans as needed. Notifications from the Blynk app enabled real-time monitoring and control. When the humidity approached 80%, the fans and servo motor continued to function , demonstrating the system's durability. This innovation product improved the drying process for mi siput by ensuring safety, efficiency, and sustainability. Drying machine able to dry mi siput within 8 hours at a temperature range of 30-40°C.

1. Introduction

In instant noodle industry, especially for small and medium enterprises (SMEs) production, the drying process is an essential step. The Malaysian local product of instant noodles, known as mi siput, is one of the local products that has a lot of potential to penetrate a new business market. Mi siput is a traditional instant noodle produced by many rural entrepreneurs in the southern region of Malaysia, particularly in Johor. The product comes in various types, shapes, formulations, and contents, made from wheat, rice, buckwheat and starches. Mi siput is produced by a dough mixing process combining six basic ingredients which are wheat flour, potato flour, sodium silicate, sodium bicarbonate, salt, and water. The purpose of applying alkaline salt to noodles is to extend their lifespan by preventing the growth of fungus [1].

Mi siput is a flour-based food product that is popular among the people of Johor, especially in Muar, Batu Pahat and Ledang district since long ago. Now mi siput is known throughout Johor and Singapore as a kind of snack. Cooked mi siput will be cooled using cold water and rinsed before winding up in a circle using aluminium mold and then dried using the traditional method under the sun's light. A smart dryer machine has been developed to solve the time consumption in noodle drying process. According to the common practice for traditional dried instant noodles, drying air temperature ranges between 29 °C and 35 °C. According to Firdaus [2], instant noodles take a whole day to dry properly. Sometimes it extends up to two days.

Food drying is a popular method for preserving fruits, vegetables, and herbs [3]. Techniques like spray drying, electro spraying, freeze-drying, and osmotic dehydration were used to preserve colour and improved food safety and quality. [4]. Freeze-drying is known for producing high-quality food products, albeit being the most expensive preservation method [5]. Additionally, the application of pre-treatments like ultrasound has been shown to improve mass transfer rates, drying efficiency and the retention of food properties such as texture and nutritional value [6]. Combined drying process of hemp includes convective pre-drying at 60 °C which reduces the unbound moisture without impacting the bioactive compounds of the raw material. Then, the vacuum-microwave finishing drying is applied to the product that brings the moisture content to the expected level. This two-stage process is more effective than each technique applied individually and results in improved quality of the product. This method has positive impacts on the quality of various fruits and herbs, including hemp [3].

In addition, dehydration techniques used for drying fruits and vegetables. These methods include mat drying, lyophilization, atomization such as spray drying, and osmotic dehydration followed by convective drying. The foam mat drying method is also known as a technique to decrease drying time and temperature of foods normally dehydrated by the traditional drying method. Microwave drying, for instance, has been successfully applied in various food processing industries, leading to energy cost savings and improved sensory and nutritional attributes of final products [7]. Innovative food drying technologies, such as photovoltaic, thermal imaging and microwave-assisted drying could improve drying efficiency [8]. Another drying technique such as encapsulation processes like freeze-drying could preserve heat-sensitive bioactive components in fruit juices, retaining their nutritious value. [9-10].

The reduction of vigor in seeds subjected to artificial drying causes intense changes such as crystal formation and disappearance of the vacuole and endomembranes, as shown in ultrastructural analyses. Furthermore, during storage, particularly when the seeds were subjected to water loss of 40% in both types of drying and 5% in the static dryer, seed vigour was reduced. [11]. In contrast, it has been observed that delayed drying thermal adaptation improves survivability during spray drying. The highest survival rates of 96.4% were obtained when using 30 g of glucose and heat-adapting at 42°C for 2 hours. However, the adaptations had no impact on cells' death during storage at 37°C. These findings suggest that glucose addition and thermal adaptation can improve the survival of P. freudenreichii during spray drying and storage.

Food quality is a characteristic attribute of food that is determined by various factors such as taste, aroma, texture, appearance, nutritional value, safety, freshness, freedom from defects and contamination, and other sensory and physical properties that make food desirable for consumption. The maintenance of food quality during storage, processing, and distribution is crucial for food safety, customer satisfaction, and profitability. The sensors gather data on variables such as temperature, humidity, and quality, enabling advanced management of food quality [12].

Smart packaging with IoT sensors is critical for monitoring food quality and safety, particularly in cold storage where precise temperatures are required. [13]. IoT technology also helps producers enhance regulations and product quality by monitoring temperature, humidity, and viscosity during food fermentation [14]. IoT-based food traceability solutions are critical for maintaining food safety and quality, as well as resolving data security and accuracy concerns. [15].

Developing an automated and environmentally friendly drying machine necessitates an emphasis on sustainability, efficiency, and sophisticated technology. Smart technology, such as Industry 4.0, can help make drying operations more sustainable [16]. Solar drying methods have demonstrated potential in promoting sustainability in agricultural drying by using renewable energy sources [17]. Moreover, the advancement of economical and effective solar drying systems can greatly enhance intelligent agricultural methods, fostering sustainability in the realm of food production [18]. Moreover, technologies like pulsed electric fields (PEF), as reviewed by [19], can enhanced drying rates, improved mass-energy transfer, retain bioactive compounds, and enhance osmotic dehydration in food. The elimination of energy-intensive drying steps through technological approaches like "dry coating," as discussed by [20], lead to significant energy savings in food production processes.Furthermore, the integration of dry and wet fractionation processes, as proposed by [21], improved component separation efficiency, minimize waste and provide added value to food products. Technologies such as foam-mat drying, as mentioned by [19], can enhance the utilization of plantain in various food applications, contributing to sustainability.

2. Material and Methods

An efficient and environmentally friendly wireless drying system, powered by solar panels. As the system works, it could charge the battery using solar energy. The solar panel provides power, the light bulb will emit heat to dry the mi siput and the DC fans speed up the drying system by circulating heat. In addition, the rain sensor also function to detect rain and the DHT22 sensor monitored temperature and humidity. Solar panels convert sunlight into electricity, which powers the entire system. The system automatically adjusts heating and ventilation depending on temperature and humidity readings to optimized conditions for consistent drying and high-quality output. The machine combines several sub-systems and provides a wireless system that is both efficient and sustainable. This system has been powered by solar panels, guaranteed a consistent power supply while also providedwarmth, ventilation, rain protection, and humidity control.

In humidity control, DHT22 sensors, rain sensors, ESP32 microcontrollers, relays, fans and servo motors are all components that work together to achieve optimal humidity levels. A DHT22 sensor, combined with an ESP32 microcontroller, has been designed to measure ambient humidity. The ESP32 analyzes the data by comparing the humidity level to a preset threshold. The ESP32 reads the signal from the DHT22 and sends it to the appropriate relay, which turns the fan on or off based on what is needed to speed up the drying process. When the humidity reaches a certain threshold, the ESP32 will issue an additional control signal to active the servo motor. The servo motor then performs mechanical actions such as opening or closing the airflow to regulate the humidity in the area where it works. The rain sensor also connected to ESP32 which function to close the lid when the rain occurred. Figure 1 shows a block diagram of the humidity control and monitoring system.

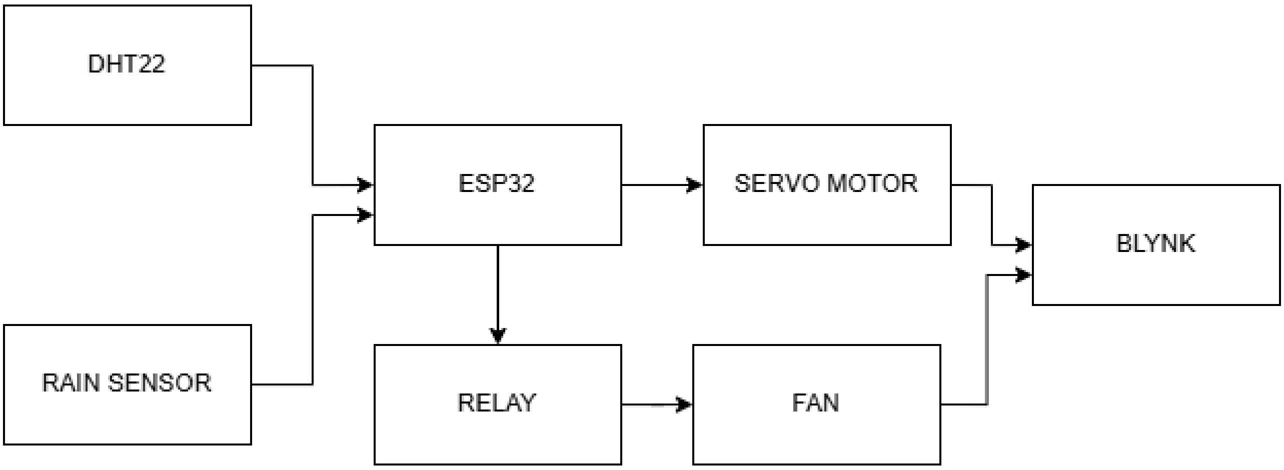


Fig. 1: Block diagram of humidity control system

In heating control the system has been designed to manage and monitor ambient temperature using a DHT22 sensor, an ESP32 microcontroller, relays, three lamps, two fans, and the Blynk application. The DHT22 sensor continuously measures temperature and humidity in real-time, then sends the data to the ESP32 microcontroller. The ESP32 processes the data and decides whether to activate the lamp based on preset temperature thresholds which is temperature above 50°C. Then, the ESP32 sends signals to the respective relay to switch the lamp on or off to heat the inner machine as desired. Additionally, the ESP32 has been connected to the Blynk application, which provides a user-friendly interface application for real-time monitoring of temperature and humidity. Figure 2 shows a block diagram of heating control and monitoring system.

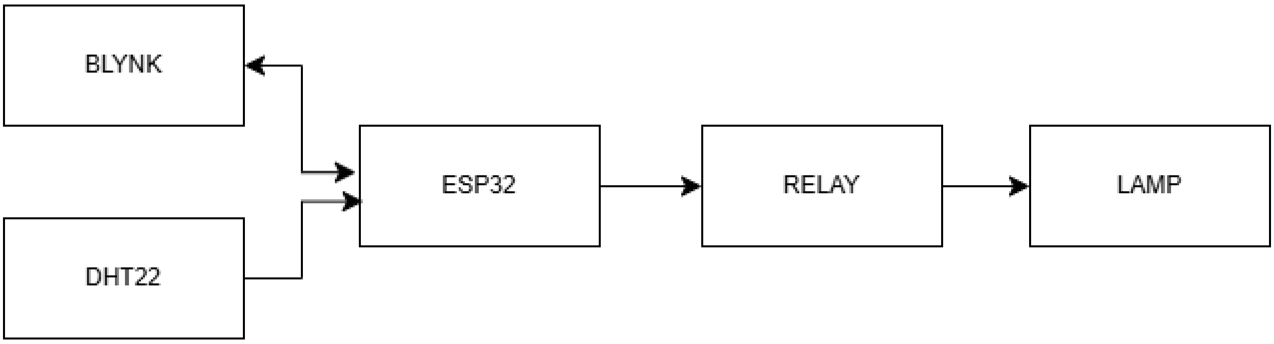
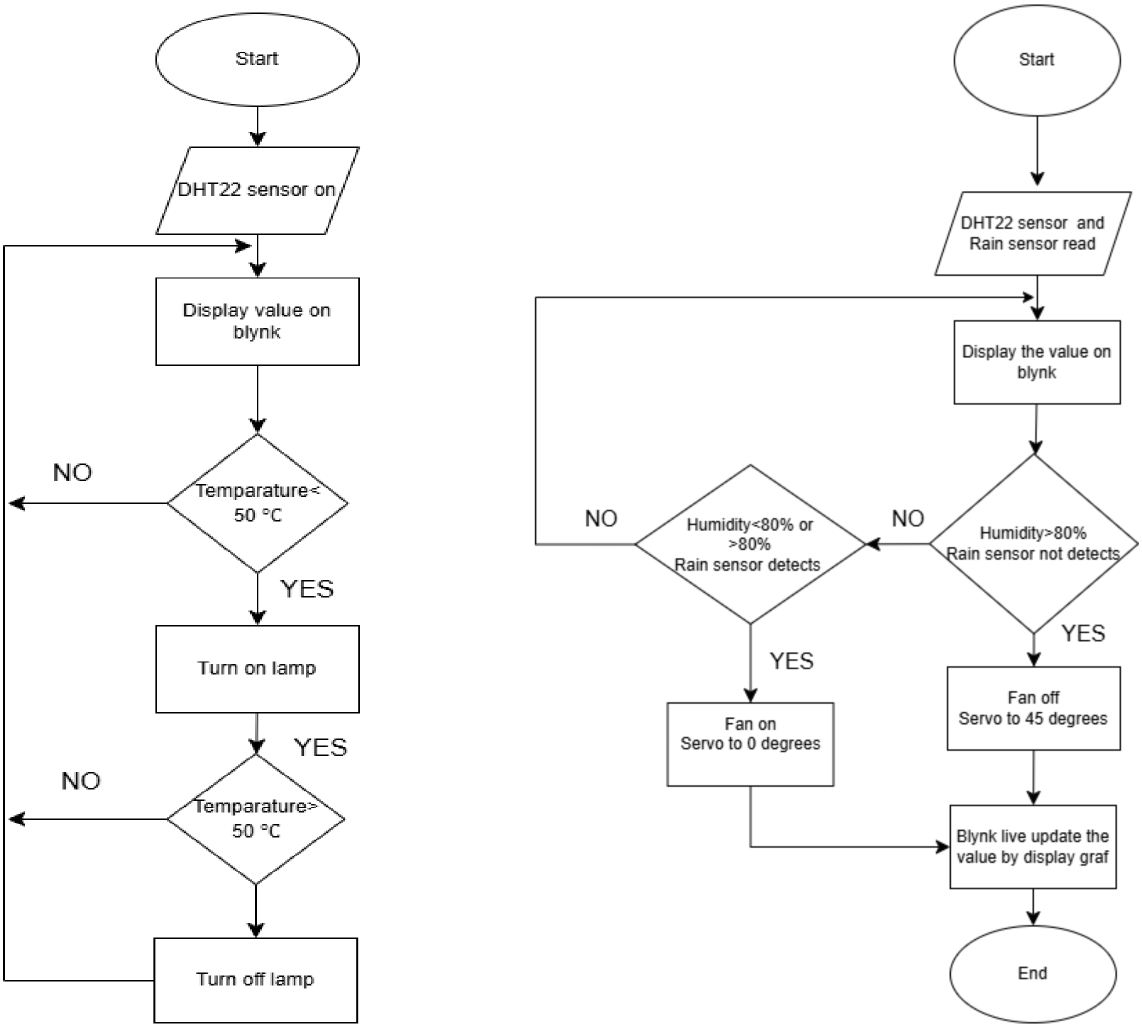


Fig. 2**:** Block diagram of heating control system

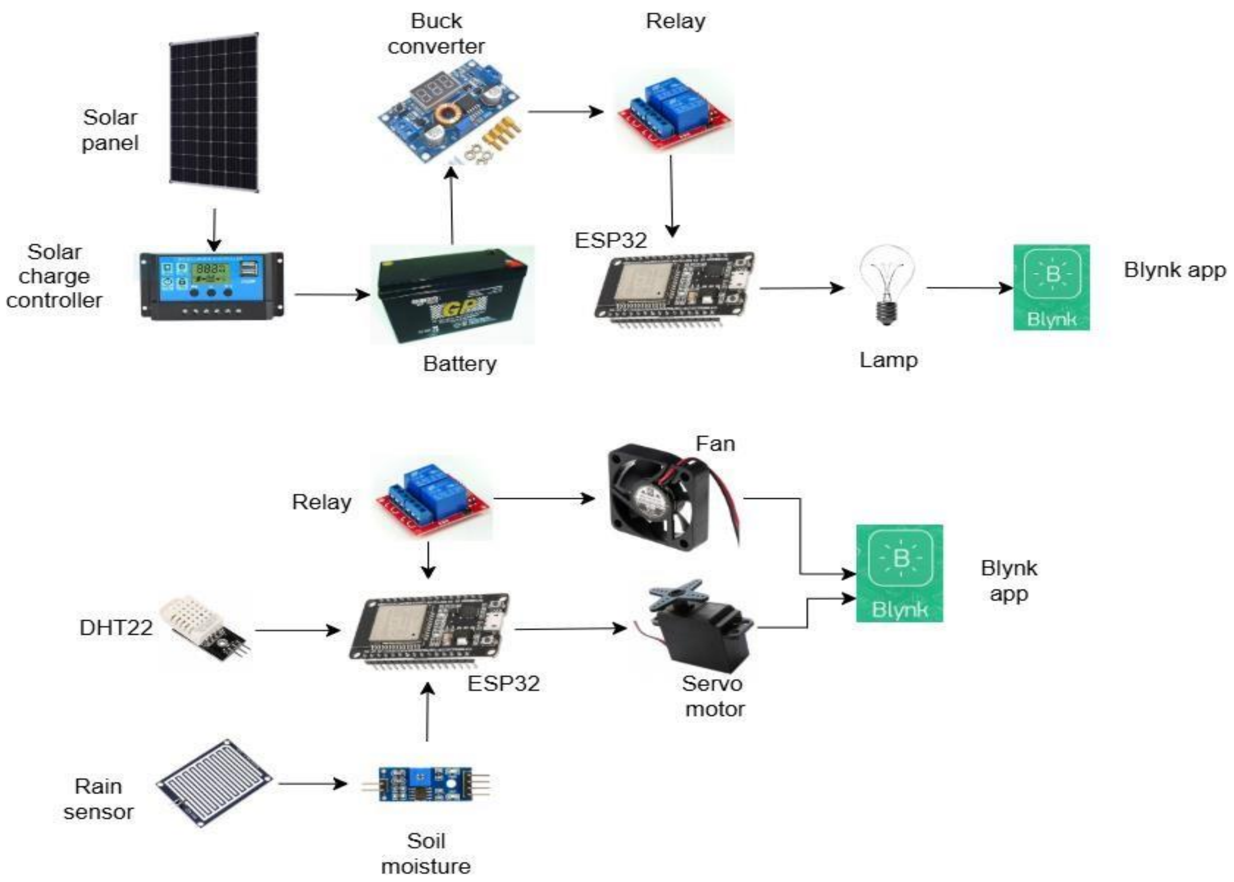
Figure 3 shows the flow of heating control and humidity control. For heating control, the process starts from temperature from the DHT22 sensor collecting temperature reading. Based on the sensor readings, the system decides whether to turn on or off the lamps. The threshold value for the temperature has been set to 50 °C. If the temperature reading falls below 50°C, all the lamps are triggered to aid in the drying process. Conversely, if the temperature rises beyond 50°C, the lights are shut off to save energy and prevent overheating. Additionally, sensor readings and the lamps condition has been provided to the Blynk app for real-time monitoring. For humidity control, DHT22 has been used to provide the current humidity level inside level the machine. If rain is detected, the servo goes to 0 degrees meaning closed the lid to protect the mi siput inside the machine from being wet, and the fan activates. If the humidity exceeds 80%, the servo rotates to 45 degrees to open the lid to remove the moisture. Users can also control the servo motor manually using the Blynk app.



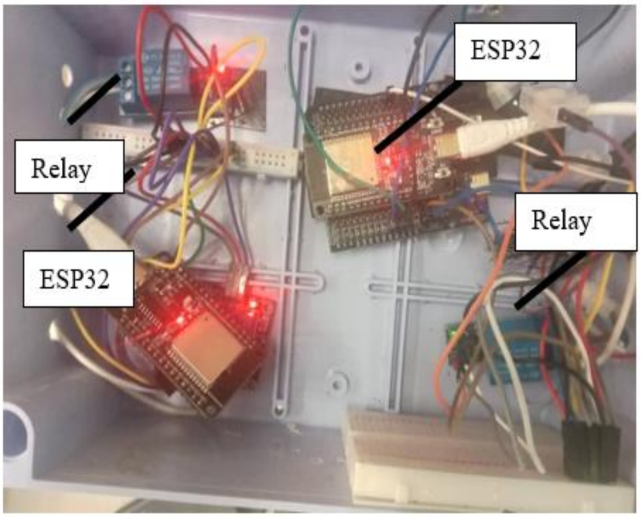
(a) (b)

Fig. 3**:** (a) Flowchart of the heating control (b) Flowchart of the humidity control

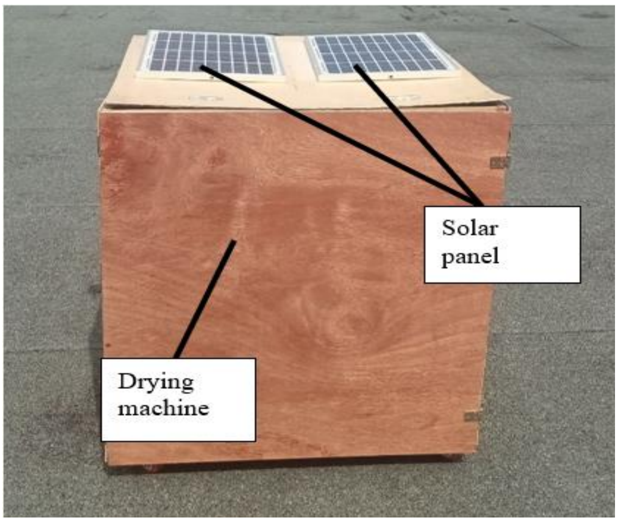
Figure 4 shows experimental setup of the project. The solar panel has been connected to the solar charge controller to charge the battery. The DHT22 sensor connected to ESP32 for humidity measurement, and the ESP32 has been connected to Blynk application for real-time monitoring. The ESP32 also has been connected to relay for controlling servo motor, lamps, and DC fans. The rain sensor also has been connected to the ESP32.Once the rain sensor detects rain drop moisture, it will activate and send a notification to Blynk application.



(a)



(b)



(c)

Fig. 4: (a) Experimental setup of the project (b) Hardware connection (c) Final drying machine product

3. Results and discussion

The experiments have been conducted for three times. In the first experiment, the mi siput was dried for 2 hours within temperature range 34.9°C to 38.3°C. From this experiment, it was found that the mi siput did not dry. The mi siput was then removed from the machine and dried at room temperature. After a week, it was found that the mi siput still not dry at room temperature even though it takes a week. Figure 5 shows comparison of temperature and humidity for the first experiment. Apparently, from this experiment the temperature is just 39.7 °C and from this temperature it is not hot enough to make mi siput dry within 2 hours. Additionally, the reading of humidity is 76 % meaning that the mi siput is still wet. This means that the the mi siput will never dry in room temperature. Table 1 shows the mi siput in the first experiment, where it was not dried within 2 hours in the machine.

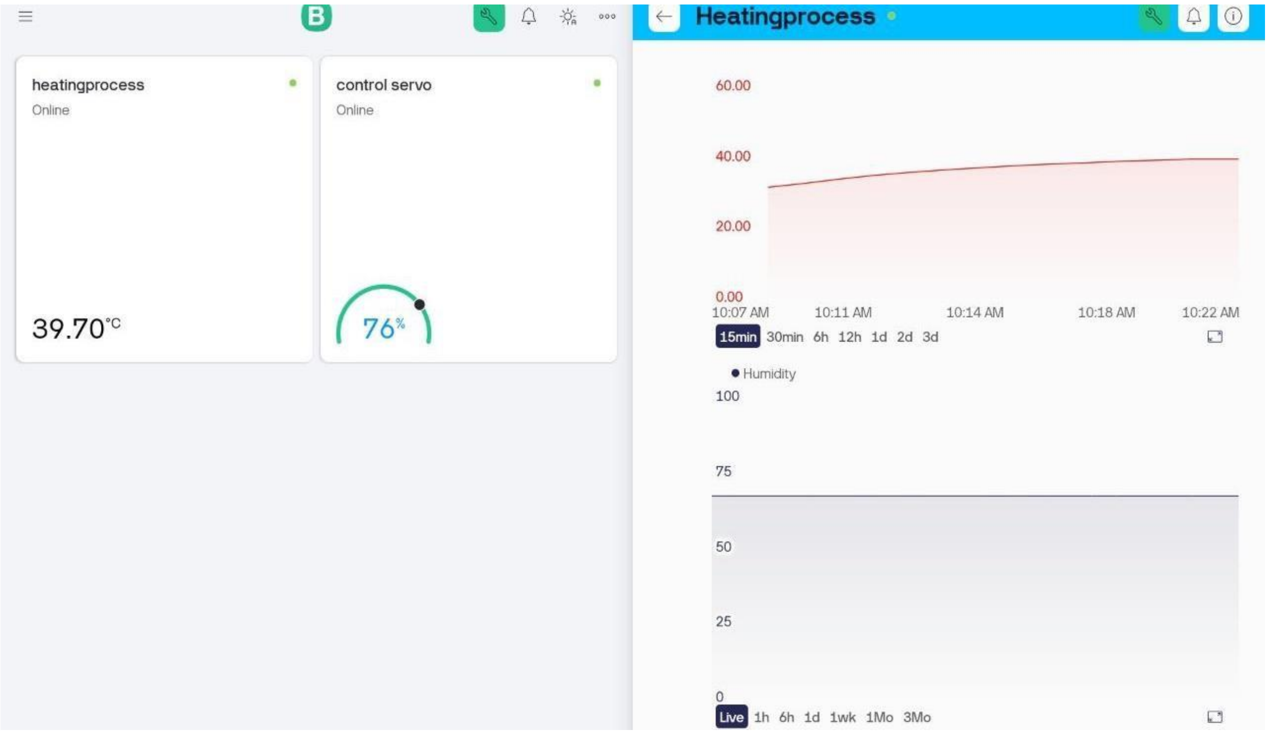


Fig. 5**:** Temperature and humidity comparison

Table 1**:** The condition mi siput before and after dried in the machine within 2 hours in the first experiment

	Before dry in the machine	After 2 hours in the machine
Figure drying mi siput		
Temperature	34.9 Celcius	38.3 Celcius
Humidity	83%	78%

Penerbit UTHM

The second experiment was conducted by drying the mi siput for 8 hours in 2 consecutive days and the results shown in table 2. The experiment started on the first day and the mi siput was dried in the machine for 4 hours. After that,it was found that the mi siput was only partially dry and drying process continued in the next following day for another 4 hours and it was found that the mi siput was completely dry. It can be said that the mi siput can be completely dried using the proposed drying machine within 8 hours.

Table 2**:** Mi siput dried after 8 hours in the second experiment

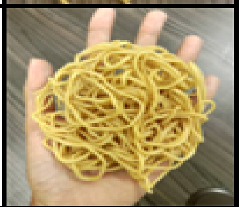
DATE	TIME	CONDITION	TEMPERATURE	HUMIDITY	FIGURE
DAY 1	11:00 AM	It's still wet	45.9 celcius	82 Percent	
	3:00 PM	Half dried	40 celcius	75 Percent	
DAY 2	10:00 AM	Half dried	42 celcius	74 Percent	
	2:00 PM	Dried	40.1 celcius	61 Percent	

Figure 6 shows the reading of the temperature and humidity in second experiment. From this experiment it shows that the temperature is 40.9 °C so user can know that the temperature in the machine is hot and efficient to dry the mi siput. In addition, for the reading of humidity after 8 hours drying process, the reading shows 67 % meaning that the mi siput in the mi siput in the machine was totally dry.

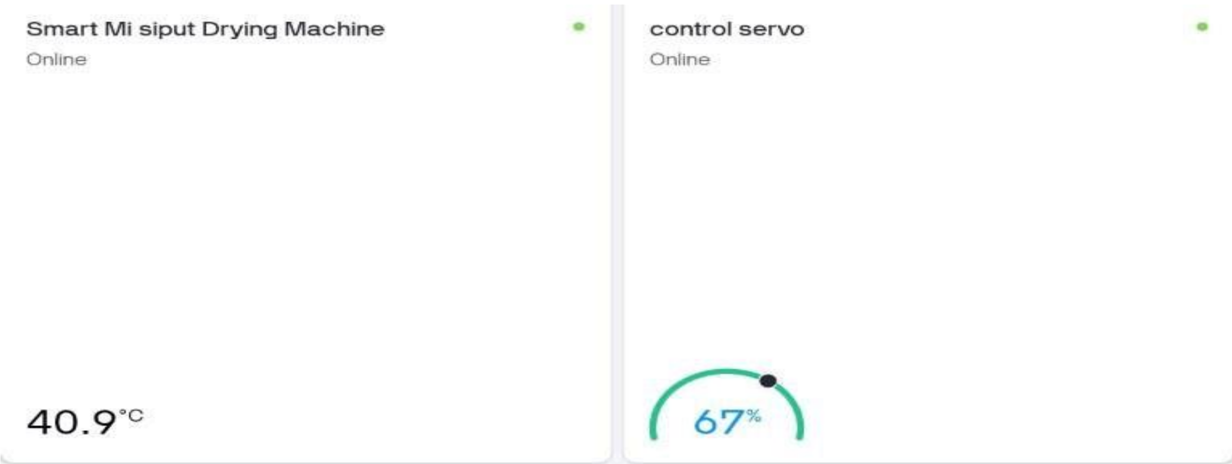
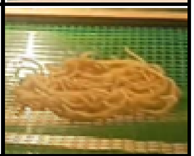
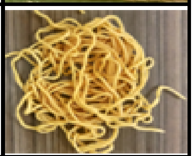


Fig. 6**:** Temperature and humidity comparison reading in the second experiment

The third experiment was carried out for 8hours in 2 consecutive days, and the results are shown in table 3. On the first day, the mi siput was dried for 5 hours, starting from 10 am and ending at 3 pm. Drying was resumed the next day for 3 hours starting from 10 am until 1 pm. After 8 hours of drying, it was found that the mi siput was completely dry. This is in line with the findings from the second experiment, which was that drying process was successfully carried out for 8 hours. If drying process has started on the same day at an earlier time, for example at 9 am, then by the same day, the mi siput can dry without the need for heating at night at night as traditional method conducted.

Table 3: Mi siput dried after 8 hours in the third experiment

DATE	TIME	CONDITION	TEMPERATURE	HUMIDITY	FIGURE
DAY 1	10:00 AM	It's still wet	42 celcius	74 Percent	
	3:00 PM	Half dried	39 celcius	70 Percent	
DAY 2	10:00 AM	Half dried	40.1 celcius	70 Percent	
	1:00 PM	Dried	40 celcius	64 Percent	

Conclusion

In conclusion, a sustainable mi siput drying machine utilizing solar panel and IoT was developed to meet all the stated aims of the project. The system is designed to be equipped with a solar-powered battery charging mechanism to make the entire unit energy-autonomous, eco-friendly, maintain uniform drying conditions and increase convenience in handling and mobility for the user. The tests performed under a variety of conditions proved that the system was able to function well, managing to dry the mi siput within 8 hours. This system integrates sustainability, automation, and remote control into the mi siput drying machine to reduce environmental impact and improve user experience.

Acknowledgement

This research was supported by the Ministry of Higher Education (MOHE) through the Fundamental Research Grant Scheme (FRGS/1/2022/TK07/UTHM/02/3). The authors would like to thank the Faculty of Engineering Technology, University Tun Hussein Onn Malaysia for providing the necessary research facility for this study.

References

[1] Mamat, K. A., Yusof, M. S., Hassan, S., & Yusoff, W. F. W. (2016). Temperature and humidity determination for dried instant noodle drying machine. ARPN Journal of Engineering and Applied Sciences, 11(12), 7853-7857.

[2] Fathi, F., N. Ebrahimi, S., Matos, L. C., PP Oliveira, M. B., & Alves, R. C. (2022). Emerging drying techniques for food safety and quality: A review. Comprehensive Reviews in Food Science and Food Safety, 21(2), 1125-1160.

[3] Singh, B., Panesar, P. S., Nanda, V., & Kennedy, J. F. (2010). Optimisation of osmotic dehydration process of carrot cubes in mixtures of sucrose and sodium chloride solutions. *Food Chemistry*, *123*(3), 590-600.

[4] Ahmad, F., Mohammad, Z. H., Zaidi, S., & Ibrahim, S. A. (2023). A comprehensive review on the application of ultrasound for the preservation of fruits and vegetables. *Journal of Food Process Engineering*, *46*(6), e14291.

[5] Petikirige, J., Karim, A., & Millar, G. (2022). Effect of drying techniques on quality and sensory properties of tropical fruits. *International Journal of Food Science & Technology*, *57*(11), 6963-6979.

[6] OLIVEIRA, V. S. D., Donadon, J. R., Guimarães, R. D. C. A., & Hiane, P. A. (2021). Application of dehydration technologies as a tool to foster bioeconomics and fruit consumption in rural populations in South America. *Food Science and Technology*, *42*, e14021.

[7] Mahalakshmi, M., & Meghwal, M. (2022). Microencapsulation of fruit juices: techniques, properties, application of fruit powder.

[8] de Boer, F. Y., Imhof, A., & Velikov, K. P. (2019). Encapsulation of colorants by natural polymers for food applications. *Coloration Technology*, *135*(3), 183-194.

[9] Gaucher, F., Gagnaire, V., Rabah, H., Maillard, M. B., Bonnassie, S., Pottier, S., ... & Jeantet, R. (2019). Taking advantage of bacterial adaptation in order to optimize industrial production of dry Propionibacterium freudenreichii. *Microorganisms*, *7*(10), 477.

[10] Abreu, L. A. D. S., Veiga, A. D., Von Pinho, É. V. D. R., Monteiro, F. F., & Rosa, S. D. V. F. D. (2014). Comportamento de sementes de cafeeiro quanto à tolerância à dessecação e ao armazenamento. *Journal of Seed Science*, *36*, 399-406.

[11] de Almeida Rios, P., de Andrade, E. T., Cardoso, D. B., & de Oliveira Silva, S. V. (2020). Colour variation in immature coffee dried under different dry bulb and dew point temperature conditions. *Research, Society and Development*, *9*(7), e539974419-e539974419.

[12] Fuertes, G., Soto, I., Carrasco, R., Vargas, M., Sabattin, J., & Lagos, C. (2016). Intelligent packaging systems: sensors and nanosensors to monitor food quality and safety. *Journal of Sensors*, *2016*(1), 4046061.

[13] Kaur, A., Singh, G., Kukreja, V., Sharma, S., Singh, S., & Yoon, B. (2022). Adaptation of IoT with blockchain in Food Supply Chain Management: An analysis-based review in development, benefits and potential applications. *Sensors*, *22*(21), 8174.

[14] Gonzalez-Amarillo, C., Cardenas-Garcia, C., Mendoza-Moreno, M., Ramirez-Gonzalez, G., & Corrales, J. C. (2021). Blockchain-iot sensor (Biots): A solution to iot-ecosystems security issues. *Sensors*, *21*(13), 4388.

[15] Kenzhekhanova, M., Mukhametov, A., & Mamayeva, L. (2024). Optimization of production of blanched apple chips using sublimation drying. *Journal of Food Process Engineering*, *47*(5), e14650.

[16] Karami, S., & Bastarrachea, L. J. (2024). Allulose-crystallized fruits: Effect of non-thermal air-drying and UV-A light dehydration of osmotic solutions. *Journal of Food Process Engineering*, *47*(3), e14577.

[17] Rahaman, A., Mishra, A. K., Kumari, A., Farooq, M. A., Alee, M., Khalifa, I., ... & Singh, N. (2024). Impact of pulsed electric fields on membrane disintegration, drying, and osmotic dehydration of foods. *Journal of Food Process Engineering*, *47*(3), e14552.

[18] Degen, F., & Krätzig, O. (2022). Future in battery production: An extensive benchmarking of novel production technologies as guidance for decision making in engineering. *IEEE Transactions on Engineering Management*, *71*, 1038-1056.

[19] Abdel-Aal, E. S. M. (2024). Insights into Grain Milling and Fractionation Practices for Improved Food Sustainability with Emphasis on Wheat and Peas. *Foods*, *13*(10), 1532.

[20] Bhatta, S., Stevanovic Janezic, T., & Ratti, C. (2020). Freeze-drying of plant-based foods. *Foods*, *9*(1), 87.

[21] Puente-Díaz, L., Spolmann, O., Nocetti, D., Zura-Bravo, L., & Lemus-Mondaca, R. (2020). Effects of infrared-assisted refractance window™ drying on the drying kinetics, microstructure, and color of physalis fruit purée. *Foods*, *9*(3), 343.