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CORN SEED DRYER UTILISING HEATING ELEMENT AND COLOUR DETECTION WITH ESP32-CAM

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ABSTRACT

In this study, an ESP32-CAM microcontroller-based corn grain dryer was developed with the aim of increasing the efficiency of the post-harvest drying process. A faster alternative to traditional drying that still depends on the weather. This research was conducted through an experimental investigation to evaluate the impact of different drying tools and techniques on corn kernels. To determine the color of corn kernels, the tool consists of an ESP32-CAM camera, a heating element, and a K-type thermocouple sensor. The result of this research is that corn kernels can be dried more quickly and efficiently because they are not fixated on the weather. This research shows the creation of an effective ESP32-CAM-based corn dryer with color sensors, heating components, and automatic temperature control. Based on calculations, this device can dry corn kernels within 30 minutes - 2 hours to dry 0.5 kg of corn kernels, much faster than the conventional way. The ideal drying temperature range is maintained by the automatic system between 38 and 40°C. To determine when the procedure is complete, the camera successfully detects the change in color of the corn kernels from wet (yellow) to dry (golden).

*Keywords**:** Colour Detection, Heating Element,ESP32-CAM, Tensor, Corn Kernel Dryer*

INTRODUCTION

The drying process reduces the moisture content of agricultural products, which is crucial for extending shelf life, as high moisture levels make materials susceptible to microbial growth and decay due to drying (Aliyah, 2022). In addition to rice and sago, maize is a significant food crop and source of carbohydrates in Indonesia. Corn serves as both animal feed and human sustenance. Corn kernels, sometimes referred to as king grains, serve as an excellent feed component for several animal species (Hermasyah, 2022). Food and beverage enterprises alongside non-food sectors (Hudoyo and Nurmayasari, 2019). East Java Province is among the ten greatest maize-producing provinces in Indonesia, with a cultivated area of 11.9 million hectares yielding 5.37 million tons of maize (Suwarto and Prihantoro, 2020).

The study named “DHT22-based Decision Tree Forecasting Model on Smart Hydroponic Microgreen” was released in January 2024. Described the development of a system utilizing an Arduino Uno to regulate a corn seed drier, incorporating a DHT22 sensor. Designing and constructing an environmental conditioning system for a smart growing box for microgreens. Investigation: Studies indicate that the DHT22 sensor is applicable in agriculture. Nevertheless, the datasheet indicates that the DHT22 is a room sensor not designed for agricultural applications, particularly hydroponics. Consequently, concerns exist regarding the integrity of the DHT22 sensor when utilized over an extended duration (Hadi *et al*., 2024).

The primary aim of this research is to enhance the efficacy and efficiency of the maize grain drying process through the utilization of advanced technologies. Conventional drying methods include several drawbacks, including reliance on weather conditions, work effort, and variability in quality. We aimed to surmount these limitations while preserving optimal maize quality and moisture levels through the development of an automated drying system.

Typically, daily labor is employed to desiccate maize kernels. Nonetheless, the duration required for labor and the accessible space are crucial factors in this technique. Grains with elevated moisture levels can be desiccated using one of two methods: prolonged exposure to low air temperatures or brief exposure to elevated temperatures (Jamaaluddin *et al*., 2024). Nevertheless, if the soaking procedure is conducted on water-soluble materials, the activity of microorganisms responsible for degrading or scavenging the substance will occur rapidly. Conversely, excessive manipulation of extremely thin materials may compromise the integrity of the manufactured material, affecting both its physical and chemical characteristics (Helwig and Hong, 2011; Nino and Neonbeni, 2020).

This research introduces several novel features, including color sensor technology for real-time moisture monitoring, an ESP32CAM microcontroller for precise temperature regulation and automation, the development of an energy-efficient heating system, mobile monitoring via Internet of Things integration, and sophisticated control algorithms to optimize drying duration and energy consumption (Auwali *et al*., 2023). An innovative solution, the Efficient Corn Seed Dryer with a Color Sensor-Based Heater, was developed following the identification of these issues. This device functions by utilizing a heating element to dry corn kernels. The device comprises several components and an ESP32CAM microcontroller (Anshory *et al*., 2024; Putra *et al*., 2022). During the desiccation of corn kernels. The utilization of this instrument is anticipated to facilitate the drying process of maize kernels for farmers in Indonesia.

RESEARCH METHODS

This study was conducted through experimental investigations to evaluate the impact of various drying tools and techniques on maize grain. Experimental procedures are mostly employed in fundamental research to elucidate the impact of treatments (independent variables) on outcomes (dependent variables); this study utilized both qualitative and quantitative methodologies. Naturalistic approaches yield qualitative insights, whereas experimental methods produce quantitative data for comprehensive study.

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Cochran (1957) delineated three fundamental requirements that experimental design adheres to in order to guarantee scientific rigor and evaluate equipment functionality. Initially, replication is employed to guarantee the apparatus operates reliably and to confirm that fundamental testing can be conducted. Secondly, random sampling is employed to ensure randomization, hence facilitating reliable significance testing. Third, the accuracy of experimental data is enhanced by isolating the effects of therapy from other variables by blocking principles. Testing procedures are essential to verify that the equipment's performance aligns with the specified design specifications and can consistently replicate drying conditions akin to conventional methods.

Basic Research

The initial phase involved performing an exhaustive literature review by examining pertinent references from several sources, including books, journals, articles, tutorials, and websites. The primary subjects of the literature review included heating procedures, drying processes, thermocouple systems, corn grain properties, and ESP-32 CAM technology (Ramadhan *et al.,* 2024). This theoretical framework is crucial for comprehending the requirements of system modeling and simulation. System modeling and simulation were created to validate the experimental settings based on the literature findings.

The efficacy of equipment-based drying and traditional sun drying methods was assessed concurrently throughout the implementation phase. Equipment-based drying employs a heating element that mimics temperatures akin to sun drying while offering greater variability in timing; conversely, the traditional drying method was performed over a span of 7-8 days from 8:00 am to 3:00 pm. Hourly data collection and systematic observations of the maize grain samples were conducted during the testing phase.

The final step involves analyzing and assessing the outcomes of the drying process. This involves evaluating the decrease in moisture content and monitoring the physical alterations in the maize kernels, particularly the color transition from the original wet state to the dry condition. During the inspection, critical quality indicators, like damage, splitting, or other physical alterations in the dried maize kernels, are evaluated. This study seeks to evaluate the efficacy of various drying processes while preserving the quality of maize grain through a systematic approach *(Husni et al.,* 2020; Nur *et al.*, 2022).

Design Device

The corn seed drier, as per the ESP-32 program, employs a heating element with the ESP-32 CAM for color assessment of the dried corn seeds, and utilizes a K-type thermocouple to monitor and regulate the tool's temperature, ensuring consistency. Two experiments were conducted in the production of a corn seed drier utilizing a color sensor-based heating element: one employing an ESP-32 CAM to ascertain the completion of the drying process, and the other utilizing a Type K thermocouple with an automatic shutdown system to regulate temperature. The design of the instrument is illustrated in Figures 1 and 2.

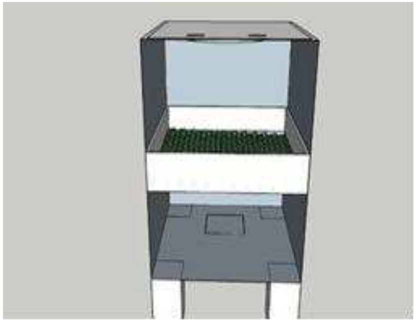

Figure 1. Design of Corn Seed Dryer Using Heating Element with ESP-32 Cam

Figure 2. Corn Seed Dryer Frame Using Heating Element with ESP-32 Cam.

The following is a circuit design of electronic components used for this tool. the design is in Figure 3.

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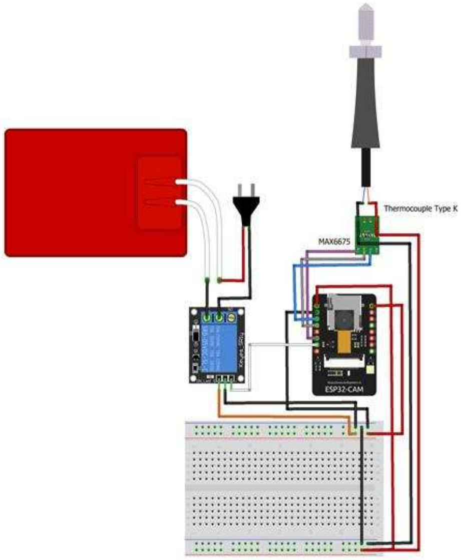

Figure 3. Schematic Circuit Design

This tool requires several components to work properly. These components are as follows:

Table 1. Electronic Component

No	Component
1	ESP 32 CAM
2	Relay 5V
3	Thermocouple Type K
4	Module MAX6675
5	Elemen Pemanas

Every component of the aforementioned circuit is crucial for the functionality of the corn grain drier in conjunction with this heating unit. The camera functions as a sensor to identify the color of the corn kernels, while the ESP-32 CAM acts as the primary processor or software hub for this device. Secondly, the system relay autonomously engages and disengages the heating element when the temperature strays from a specified range. The temperature is measured using a Type K thermocouple in conjunction with a MAX6675 temperature sensor, supplying the necessary data for relay operation.

Flowchart

The working system of this tool will be explained with the flowchat in Figure 4.

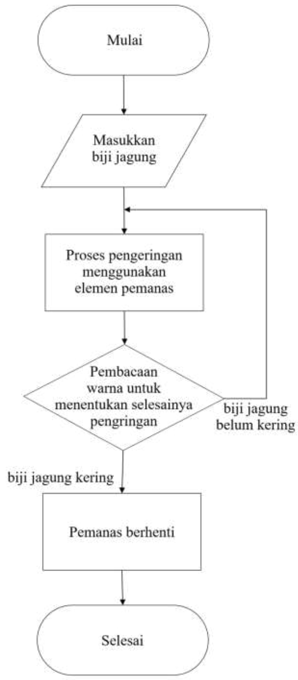

Figure 4. Flowchart System

The procedure for testing this tool entails initially uploading the software to the ESP-32 CAM. Subsequently, activate the system by pressing the reset button on the ESP-32 CAM and monitor the output via the serial interface. The heater must be connected to a power source to operate effectively. Following this, configure the temperature settings as per the program; the heater will engage if the temperature falls below 38 degrees Celsius and will deactivate when it exceeds 40 degrees Celsius. The ESP-32 CAM camera is capable of detecting the color of corn kernels. It will identify moist corn kernels upon their insertion. The application will terminate and the process will conclude once dry corn kernels are detected, which is expected to occur within one to five hours.

RESULT AND DISCUSSION

Instrument testing data helps determine if the instrument operates as intended and if its benefits meet expectations. The initial test pertains to the heating element system that autonomously activates and deactivates when the temperature exceeds or falls below a specified threshold. The corn kernel color assessment system was subsequently evaluated. Data from the serial monitor was collected when the Arduino IDE was activated and the

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maize was nearly dry. The information from the serial monitor is presented in Table 2.

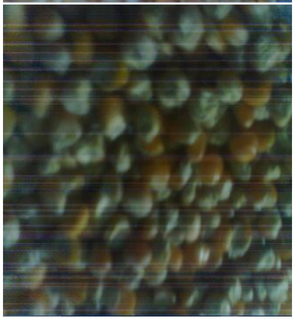
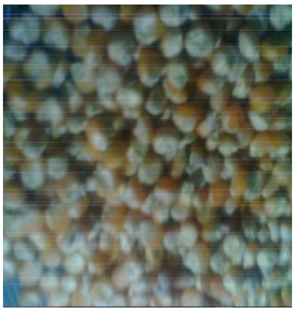
Table 2. Auto Shut-Off With Heating Element And Color Detection

No	Temperature (C)	Element Condition	Corn Grain Condition
1	30.00	ON	WET
2	30.00	ON	WET
3	37.50	ON	WET
4	38.25	ON	WET
5	38.50	ON	WET
6	40.00	OFF	DRY
7	41.00	OFF	DRY
8	41.00	OFF	DRY

The test results indicate that the heating element demonstrates reliable temperature regulation. Upon activation of the heating element, the starting temperature increased from 27 to 38°C. The equipment demonstrated a swift escalation in dryer temperature, with the maximum limit regulated at 40°C. Upon reaching this temperature threshold, the heating element promptly deactivates until the temperature falls below 40°C, illustrating efficient temperature regulation. This automated temperature regulation guarantees uniform drying conditions during the entire procedure.

Following the assessment of the corn kernel drier system's efficacy, the subsequent test aimed to determine whether the corn kernels dried at a rate comparable to that of direct sunshine exposure. The test is conducted by examining the photographs displayed by the ESP-32 CAM camera. The camera data will be examined hourly to observe the color variation. At this step, the test is conducted three times for durations ranging from 30 minutes to 2 hours to ensure the acquisition of accurate findings. The following test results pertain to the corn grain drying experiment. The results are presented in Table 3.

Table 3. Color Test Results On Corn Kernels

No	Time	Corn Grain Condition	Serial Monitor
1	08:00		WET
2	09:00		WET
3	10:00		WET
4	11:00		WET
5	12:00		WET

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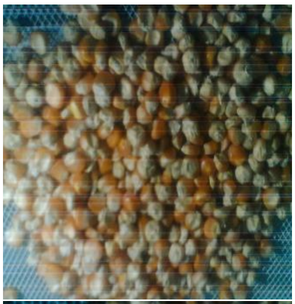
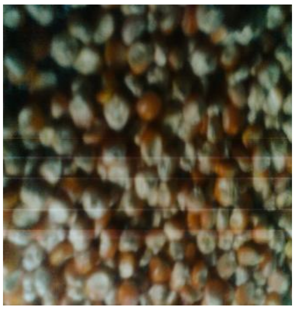
6	13:00		WET
7	14:00		DRY
8	15:00		DRY

The data analysis indicates that the color variation of maize kernels from the initial to the final test is minimal, although it is distinctly perceptible to both the camera system and the human eye. Throughout the data collection process, the maize kernels were regularly agitated to guarantee uniform drying and precise color identification of each kernel. The shaking process is crucial during color inspection to ensure that the maize kernels are entirely dry and that color readings are conducted comprehensively.

The color detecting device differentiates between wet and dry corn kernels through video surveillance. Upon the introduction of moist maize kernels into the dryer, the system camera effectively identifies them and presents the "WET" status on the serial monitor. During the drying process, the equipment incessantly observes the color transformation of the maize kernels. Upon achieving the requisite dryness of the maize kernels, the camera identifies the color alteration and updates the serial display status to “DRY”. The detection of color change prompts the heating element to deactivate automatically, thereby gradually reducing the temperature to its original level. The system's capacity to promptly resume upon the introduction of more wet maize kernels illustrates a continuous cycle between wet and dry circumstances.

This automated drying system offers several advantages over older methods that lack automation capabilities. The integration of color detection and sophisticated temperature regulation accelerates the drying process relative to direct sunshine exposure while safeguarding from fowl interference. Automation enhances production throughout the drying process by removing the necessity for manual oversight. This research presents excellent prospects for future advancement. The efficacy of the color detecting system can be enhanced by incorporating additional automation elements, such as an automatic sorting mechanism, to elevate the quality of the dried maize kernels. This advancement may markedly enhance the efficiency of the drying process and ensure consistently superior outputs. These prospective enhancements illustrate the system's versatility and receptiveness to forthcoming advancements in automated agriculture processing.

Implementing stirring mechanisms to enhance drying uniformity, integrating mobile applications for remote monitoring, and developing post-drying sorting systems for quality control can all enhance the system. The incorporation of moisture content sensors and the enhancement of the system's capacity, while preserving efficiency, would be beneficial for larger agricultural enterprises. The suggested enhancements, in conjunction with the automated functionalities and sophisticated monitoring capabilities of the existing system, signify a substantial progression beyond conventional techniques and standard commercial dryers. This research employs unique methodologies that provide Indonesian farmers a potential means to achieve superior maize yields and enhance productivity, a crucial advancement in agricultural modernization.

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CONCLUSION

This study demonstrated the effective creation of an ESP32-CAM-based maize dryer with color sensors, heating components, and automated temperature control. The system can dry 0.5 kg of corn kernels in 30 minutes to 2 hours at a steady temperature of 38-40°C, which is significantly more efficient than the traditional approach, which takes 7-8 days. In addition to saving time, it protects crops from animal contamination and can work 24 hours a day, making it a viable alternative for Indonesian farmers. Future improvements to the system include an automated stirring mechanism, mobile application integration for remote monitoring, a post-drying sorting system, a moisture content sensor, and expanded capacity, which will help larger-scale agricultural operations.

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