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Development of Dual Source Micro-Controller based Flatbed Dryer for Corn Grains

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Abstract: *The ultimate goal of this research is to close the gap between conventional drying techniques and contemporary agricultural innovations, hence enhancing food security and corn growers' profitability. Future technological advancements in grain drying and storage solutions will be built upon the results of this study. The prototype received a great evaluation due to its outstanding functionality. This shows that the power management system is quite effective at detecting electrical problems and responding to both high and low voltage. This device is highly regarded for both home and business applications because to its adaptability and versatility. It meets user expectations, efficiently attends to particular demands, and offers a secure and hands-on learning environment for power management system knowledge.Users expressed satisfaction with the device's use as well as the availability of resources, including tools, materials, and assistance. Although the tool's capacity to offer worthwhile educational experiences scored marginally lower, there is still room for improvement. Users gave the item good marks for longevity because it showed a strong resilience to external variables, high temperatures, and deformation. The tool's lifespan is guaranteed by this sturdy framework, which qualifies it for extended usage. Users thought the prototype was great since it prioritized safety. The device puts user well-being first by removing sharp edges, staying away from hazardous chemicals, and adding safety features including sufficient protection and unambiguous instructions, which makes it appropriate for educational settings.*

Keywords: Dual Source, Micro-Controller, Flatbed Dryer, Corn Grains

I. INTRODUCTION

Corn ranks second to rice, not only in terms of area devoted to its production but it has been a staple food of about 20% of the total population of the Filipi`nos(ATI.DA, 2024).Growing corn is an interesting venture for farmers (Villaver, 2020).The agricultural sector, particularly corn production, is a cornerstone of many economies, especially in rural areas. Asides its usefulness to humans, maize is also an important component of many animal feeds (Lawal,et al.,2024). However, maize drying is a serious problem in tropical maize growing countries. For example, sun drying is a common practice at farm level in many countries although it requires large space, a huge number of labors and a long time to dry this product and results in postharvest losses as high as up to 30 % (Doymaz, et al.,2024). Agriculture remains a vital sector in ensuring food security and economic stability, particularly in countries where corn is a staple crop. Post-harvest losses due to improper drying and storage significantly impact farmers' productivity and income.

Traditional sun drying methods are often inefficient, dependent on weather conditions, and susceptible to contamination. These challenges necessitate the development of innovative and efficient drying technologies that enhance the quality and shelf life of harvested grains.The Development of a Dual-Source Microcontroller-Based Flatbed Dryer for CornGrains aims to address these post-harvest drying inefficiencies by integrating modern technology into agricultural processing. This study focuses on designing and implementing a flatbed dryer that utilizes dual energy sources—electricity and Solar power—to ensure continuous and efficient drying of corn grains. The incorporation of a microcontroller enhances automation, allowing precise control over temperature, humidity, and drying duration, thus optimizing the drying process while minimizing energy consumption. In the Philippines, government initiatives promoting mechanized agriculture have accelerated the adoption of flatbed dryers. The Philippine Rice Research Institute (PhilRice) (2021) reported that flatbed dryers reduce drying time by up to 50% compared to traditional

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methods, preserving grain quality and reducing post-harvest losses. Despite these benefits, challenges such as uneven drying and high operational costs persist, highlighting the need for technological innovations to improve the system's efficiency (Torres et al., 2023).

Recent technological advancements in energy and automation systems have paved the way for dual-source energy-powered drying systems, which integrate renewable energy with conventional sources. Kapur et al. (2021) demonstrated that hybrid energy systems significantly reduce operational costs and carbon footprints, offering a reliable solution for areas with inconsistent sunlight. Furthermore, Cruz et al. (2022) found that dual-source systems in grain drying could reduce fuel consumption by 35% while maintaining consistent drying temperatures. By developing a cost-effective, energy-efficient, and easily operable drying system, this research seeks to provide small- and medium-scale farmers with an alternative drying solution that enhances grain quality, reduces losses, and improves market value. The study will evaluate the efficiency, performance, and economic feasibility of the proposed system, contributing valuable insights into sustainable post-harvest

Ultimately, this research aspires to bridge the gap between traditional drying methods and modern agricultural advancements, promoting food security and increasing profitability for corn farmers. The findings of this study will serve as a foundation for future technological improvements in grain drying and storage solutions. processing technologies.

II. REVIEW OF LITERATURE

Drying is a critical post-harvest process in agricultural production, especially for corn grains. It reduces moisture content to a safe level for storage and transportation, minimizing spoilage and ensuring grain quality. Solar drying is popular in the tropical region, owing to ample availability of solar energy, simplicity in design and construction, and associated cost-effectiveness (Ananno et al., 2020). With few exceptions, most countries of the developing world are located in climatic zones receiving reasonably higher insolation than the world average figure that varies from 1600 to 2200 kWh/m2/year (Vanitha et al., 2019). However, traditional sun drying methods, commonly used in rural areas, are highly weather-dependent and inefficient. To address these challenges, the development of flatbed dryers has become a practical solution, offering consistent drying performance and enhancing post-harvest efficiency. Recent advancements in this technology underscore its relevance, particularly in regions prone to weather variability. (Mujumdar et al. 2020), emphasized that flatbed dryers significantly reduce grain spoilage and improve drying consistency, especially in rural areas with limited infrastructure.

Flatbed Drying Systems for Corn Grains

Drying is a crucial post-harvest process in agricultural production, particularly for corn grains. According to Bassey (2016), flatbed dryers are commonly utilized in small- to medium-scale agricultural operations due to their simplicity and effectiveness. Flatbed dryers operate by directing heated air through a perforated platform holding the grains, ensuring even drying and reducing post-harvest losses. Research conducted by Mujumdar et al. (2020) highlights that these systems are particularly advantageous in rural areas where traditional sun drying is unreliable due to weather variability.

In the Philippines, flatbed dryers have been widely adopted in response to government initiatives promoting post-harvest technology. A study by PhilRice (2018) indicates that flatbed dryers reduce drying time by 40-50% compared to sun drying, improving efficiency and maintaining the quality of dried grains. However, challenges such as uneven drying and high fuel consumption remain significant drawbacks (Bernabe et al., 2021).

Dual-Source Microcontroller-Based Flatbed Dryer

The study focuses on the development of a dual-source microcontroller-based flatbed dryer for corn grains, utilizing electricity and solar energy as primary power sources. The integration of a microcontroller allows for real-time monitoring and precise control over drying parameters such as temperature and humidity, optimizing the drying process and reducing energy consumption. The system is designed to provide an alternative solution for small- and medium-scale farmers, ensuring efficient and sustainable post-harvest drying.

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- **Design and Fabrication:** The dryer is designed to operate using both electric and solar power, incorporating energy-efficient components and a user-friendly interface.
- **Microcontroller Integration:** A microcontroller is programmed to regulate drying parameters, ensuring uniform drying and preventing overheating.
- **Testing and Performance Evaluation:** The dryer's efficiency is assessed based on drying time, energy consumption, and grain quality.
- **Comparative Analysis:** The developed system is compared with traditional drying methods to evaluate its benefits and limitations.

Technological Innovations in Grain Drying

Modern innovations in grain drying focus on enhancing efficiency and sustainability. Sanni et al. (2021) explored the use of IoT (Internet of Things) technologies in flatbed dryers, enabling remote monitoring and control of drying operations. This approach minimizes the need for manual intervention and reduces operational errors.

Furthermore, Patel et al. (2020) highlighted the potential of integrating AI (Artificial Intelligence) algorithms into drying systems to predict optimal drying times and prevent over-drying, which can degrade grain quality. These advancements align with the goals of sustainable agriculture by reducing energy consumption and minimizing post-harvest losses.

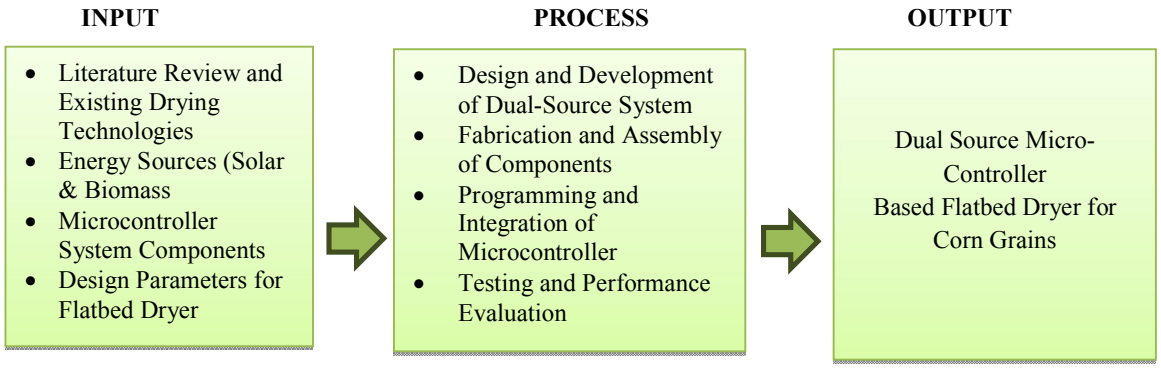
Gaps Challenges in Corn Grain Drying

Despite advancements, several challenges remain in the drying of corn grains. Ogundare et al. (2018) identified uneven drying as a persistent issue in flatbed dryers, often caused by inconsistent airflow distribution. Additionally, high initial costs of dual-source systems and microcontroller-based technologies may deter small-scale farmers from adopting these innovations (Garcia et al., 2020).

- **Energy Efficiency:** Many existing dryers are energy-intensive, increasing operational costs for farmers.
- **Automation and Precision:** Traditional drying methods lack automation, leading to inconsistent drying results.
- **Affordability and Accessibility:** High initial costs of modern drying systems make them inaccessible to small-scale farmers.
- **Environmental Sustainability:** Dependency on fossil fuels for drying contributes to carbon emissions and environmental degradation.

III. CONCEPTUAL FRAMEWORK

The study follows the Input-Process-Output (IPO) Model to conceptualize the development of a Dual-Source Microcontroller-Based Flatbed Dryer for corn grains.



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Input

The input phase consists of the foundational elements required for the development of the Dual-Source Microcontroller-Based Flatbed Dryer. These include:

- Literature Review and Existing Drying Technologies – Research on conventional and modern drying methods to identify best practices and areas for improvement.
- Energy Sources (Solar) – Utilizing both renewable (solar) and conventional energy to ensure efficient drying
- Microcontroller System Components – Incorporating automation through sensors and controllers to regulate drying conditions such as temperature and humidity.
- Design Parameters for Flatbed Dryer – Establishing technical specifications for the drying chamber, airflow system, and heating elements to optimize drying performance.

Process

The process phase outlines the systematic steps involved in developing the drying system:

- Design and Development of the Dual-Source System – Creating the structural and functional blueprint of the dryer.
- Fabrication and Assembly of Components – Constructing the physical components, including the drying chamber, power supply, and control unit.
- Programming and Integration of Microcontroller – Implementing automation features by programming sensors and control mechanisms for efficient drying management.
- Testing and Performance Evaluation – Conducting experiments to assess drying efficiency, energy consumption, and grain quality, ensuring the system meets performance standards.

Output

The expected results of the study include:

- Efficient Dual-Source Microcontroller-Based Flatbed Dryer – A fully functional drying system that effectively utilizes both solar and biomass energy.
- Improved Drying Efficiency for Corn Grains – Reduced drying time while maintaining the nutritional value and quality of the grains.
- Sustainable and Cost-Effective Drying Solution – A system that minimizes operational costs for farmers while promoting environmental sustainability.

The IPO model clearly outlines how the study integrates renewable and conventional energy sources with automation technology to develop an efficient, sustainable, and cost-effective drying system for corn grains. This innovation addresses key challenges in post-harvest management and contributes to improving agricultural productivity.

Statement of the Problem

The study "Development of Dual-Source Microcontroller-Based Flatbed Dryer for Corn Grains" aims to address inefficiencies in traditional drying methods by integrating both solar and electrical energy sources with a microcontroller-based system for improved automation and efficiency Specifically and it Anchored in the Input-Process-Output (IPO) conceptual framework, this study seeks to answer the following research questions:

- What are the existing challenges in traditional corn drying methods in terms of energy efficiency, automation, cost, and drying performance?
- How can a dual-source (solar and electrical) system be effectively designed and developed to optimize the drying process?
- What are the necessary microcontroller components and programming techniques required to automate and regulate drying conditions such as temperature and humidity?
- How does the developed system compare with conventional drying techniques in terms of drying time, energy consumption, and grain quality?

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- What is the overall efficiency, cost-effectiveness, and sustainability of the dual-source microcontroller-based flatbed dryer?

This study aims to bridge the gap between traditional and modern grain drying technologies by developing a sustainable, energy-efficient, and cost-effective solution.

Significance of the Study

The Development of Dual-Source Microcontroller-Based Flatbed Dryer for Corn Grains aims to address the post-harvest challenges faced by corn farmers in Cabadbaran City, specifically the members of the Cabadbaran City Corn Growers Association (CCGAC). The findings of this study may benefit the following individuals and groups:

- **Corn Farmers and CCGAC Members**. The results of this study may provide corn farmers with an efficient and cost-effective drying solution that ensures the quality and marketability of their produce. The dual-source energy integration aims to reduce drying costs, optimize drying time, and promote sustainability, particularly benefiting the CCGAC members who rely heavily on traditional drying methods.
- **School Administrators**. The study may provide school administrators with insights into the integration of technology and agriculture, encouraging partnerships with local farmers and promoting research initiatives that address real-world problems in the community.
- **Faculty**. The findings may encourage faculty members to explore innovative technologies and solutions that can be applied to various sectors, including agriculture, thereby fostering interdisciplinary research and practical applications in their teaching.
- **Students.** This study may serve as a learning tool in students, providing them with a comprehensive understanding of how automation, renewable energy, and sustainable practices can be integrated into agricultural operations. It may also inspire future research and innovation in their academic pursuits.
- **Policymakers.** The study may highlight the need for government support in adopting dual-source microcontroller-based dryers, encouraging the development of policies, subsidies, and training programs aimed at improving post-harvest technologies for smallholder farmers.
- **Researchers.** This study may serve as their reference for researchers working on agricultural technology, renewable energy integration, and microcontroller-based automation, providing relevant data and insights for future innovations and applications.

This may also contribute significantly to the advancement of sustainable agricultural practices while empowering corn farmers with practical, efficient, and modernized drying technologies to improve productivity and profitability.

Scope and Limitations of the Study

To facilitate delimitation in understanding the purpose and content of this study, the following parameters are specified:

- **Focus.**The study focuses on developing and evaluating a Dual-Source Microcontroller-Based Flatbed Dryer for corn grains. By integrating renewable and conventional energy sources, it aims to optimize drying efficiency, reduce costs, and improve grain quality. The research assesses the system's performance, energy consumption, and usability for effective implementation.
- **Respondents.** The respondents of this study are the members of the Cabadbaran City Corn Growers Association (CCGAC), who are directly involved in corn farming and post-harvest processing. Their feedback and evaluation of the developed flatbed dryer are integral to assessing the system's practicality and acceptability.
- **Place and Time.** This study was conducted in Cabadbaran City and is focused on the members of the CCGAC during the present year, 2025.

This study is limited to the development and evaluation of the flatbed dryer in the context of its application for corn grains, particularly in rural farming practices. It does not extend to other agricultural products or drying systems beyond the specified scope.

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Definition of Terms

To facilitate clear understanding of the content and purpose of this study, the following terms are operationally described as follow:

- **Arduino.** A microcontroller platform used in this study for programming and automating the operations of the flatbed dryer, such as controlling temperature, airflow, and energy source selection.
- **Flatbed Dryer.** A post-harvest drying machine with a flat perforated surface used for drying corn grains. It directs heated air through the grains for uniform drying and minimized post-harvest losses.
- **Hybrid Energy.** The combination of renewable (e.g., solar) and conventional energy sources to power agricultural machinery, improving reliability and sustainability.
- **Microcontroller.** An integrated circuit (IC) used to automate and control various functions of the flatbed dryer, including temperature regulation, airflow adjustment, and energy source switching.
- **Dual-Source Energy System.** A hybrid power system integrating solar energy and conventional electrical energy, designed to provide uninterrupted operation of the flatbed dryer while reducing energy costs and dependence on fossil fuels.
- **Moisture Content.** The amount of water present in corn grains, which is reduced through drying to a safe level for storage and transportation.
- **Operational Efficiency.** The measure of how effectively the dual-source microcontroller-based flatbed dryer reduces drying time, energy consumption, and grain spoilage.
- **Post-Harvest Process.** Agricultural operations performed after harvesting, including drying, storage, and transportation, aimed at preserving the quality and market value of corn grains.
- **Renewable Energy.** Energy derived from natural and sustainable sources, such as solar power, used in this study to enhance the eco-friendliness and cost-effectiveness of the drying system.
- **Sensor Feedback Mechanism.** A system of sensors integrated into the flatbed dryer to monitor real-time conditions, such as grain moisture content and temperature, ensuring optimal drying performance.
- **Sustainability.** The principle of designing agricultural systems, like the dual-source flatbed dryer, to operate with minimal environmental impact and maximum resource efficiency.
- **Uniform Drying.** The consistent reduction of moisture content across all corn grains in the dryer, achieved by ensuring even airflow and temperature distribution.
- **Usability.** The practicality and ease of use of the developed flatbed dryer, focusing on its accessibility for small-scale farmers and its alignment with their operational needs.
- **Weather Variability.** Changes in weather conditions that affect the reliability of traditional sun drying methods, prompting the need for mechanized solutions like flatbed dryers.

These definitions provide clarity on the technical and operational concepts employed in the study, ensuring a comprehensive understanding of its scope and objectives.

Project Design

The Dual-Source Microcontroller-Based Flatbed Dryer aims to enhance the efficiency and sustainability of corn grain drying by integrating solar and electrical energy sources. Utilizing microcontroller technology, the system automates temperature and humidity control to ensure optimal drying conditions. This project is specifically designed to support small- and medium-scale farmers, particularly members of the Cabadbaran City Corn Growers Agricultural Cooperative (CCCGAC), by offering an affordable and effective drying solution. The objectives include designing and developing a dual-source flatbed dryer, integrating a microcontroller system for real-time monitoring, evaluating efficiency and energy consumption, comparing the system with traditional drying methods, and assessing its usability and cost-effectiveness.

The key components of the project consist of energy sources such as solar panels and electrical heating elements, a microcontroller system with sensors for temperature, humidity, and airflow control, a flatbed drying chamber for uniform heat distribution, and a user interface with an LCD display for real-time monitoring. The methodology follows

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a systematic process: research and analysis of existing drying technologies, design and development of the system architecture, fabrication of components, implementation and testing of solar and electrical integration, programming for automation, and performance evaluation based on drying time, energy consumption, and grain quality. The dryer will then be compared with traditional drying methods to optimize efficiency and reliability. The expected output includes a fully functional Dual-Source Microcontroller-Based Flatbed Dryer, enhanced drying efficiency, reduced operational costs, and a sustainable post-harvest technology. Ultimately, this project benefits corn farmers in Cabadbaran City, particularly CCCGAC members, by providing a reliable and cost-effective grain drying system that reduces post-harvest losses and improves grain quality.

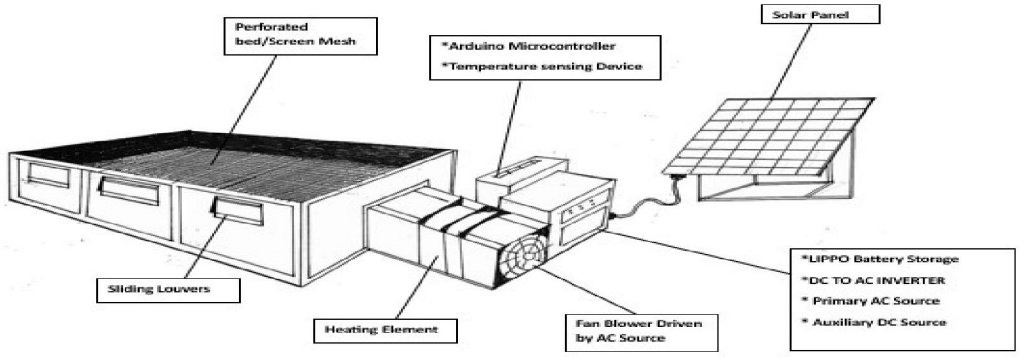

Figure 1: Micro-Controller Based Flatbed Dryer for Corn grains

The dual-source microcontroller-based flatbed dryer is an innovative grain drying system designed for efficient moisture reduction in corn grains. It integrates both conventional and renewable energy sources to optimize drying performance while ensuring sustainability and cost-effectiveness. The system employs a microcontroller-based temperature regulation mechanism to maintain optimal drying conditions, ensuring minimal energy wastage and preventing over-drying.The drying chamber consists of a perforated bed/screen mesh, allowing uniform airflow distribution through the corn grains, while sliding louvers regulate ventilation, enabling controlled moisture release. The system features a heating element that supplies the necessary heat for drying, powered either by a primary AC source or an auxiliary DC source from the solar energy system. A fan blower driven by an AC source ensures continuous airflow, facilitating the uniform drying of corn grains. This airflow prevents localized overheating and enhances the efficiency of moisture removal.To maintain precise drying conditions, an Arduino microcontroller monitors and regulates the temperature within the drying chamber, with a temperature sensing device providing real-time temperature data for accurate adjustments. The dryer operates on a dual power source system, utilizing both solar energy and conventional AC power to ensure uninterrupted operation. A solar panel harnesses renewable energy, reducing reliance on grid power and lowering operational costs, while a LiPo battery storage system stores excess solar energy for use during low sunlight conditions. A DC to AC inverter converts stored DC power into AC power for system operation.The drying process begins when corn grains are loaded onto the perforated drying bed. The fan blower initiates airflow, distributing heat evenly across the grains. The microcontroller continuously monitors temperature data and adjusts the heating element to maintain the set drying temperature. The power supply transitions between solar energy and AC power depending on availability, ensuring continuous operation. content, the system automatically stops heating, ensuring a precise and energy-efficient drying process.

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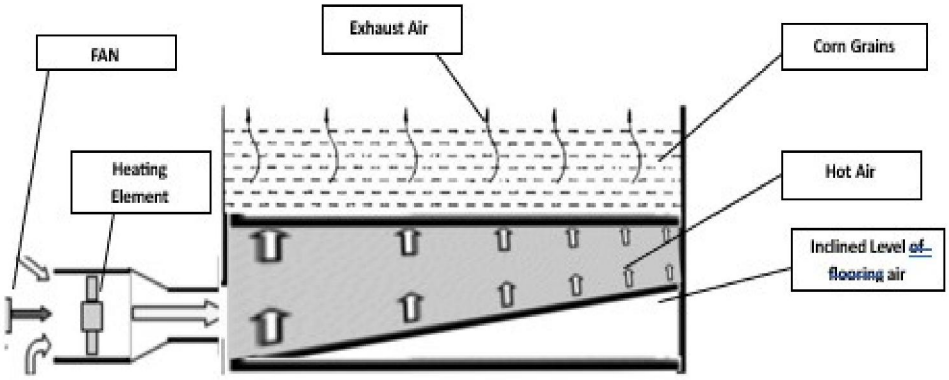

Figure 2: Schematic Front View of Dual Source Micro-Controller Based Flatbed Dryer for corn Grains

IV. RESULTS AND DISCUSSIONS

Table 1. Acceptability of the device in terms of Functionality

Criteria and Statement	Mean	Qualitative Description
A. Functionality		
Function of the device is meet as it expected.	4.83	**Excellent**
The device performs the task effectively.	4.76	**Excellent**
The device has a minimal error.	4.7	**Excellent**
The device can be enhanced or updated.	4.63	**Excellent**
Average Mean	4.73	**Excellent**

4.21 – 5.00 Excellent 3.41 – 4.20 Very Good 2.61 – 3.40 Good 1.81 – 2.60 Fair 1.00 – 1.80 Poor

The table uses four distinct statements about the functionality and performance of the device to evaluate the "Functionality" criterion. Each claim outlines a unique feature of the device's operation. The average ratings or scores assigned to each statement are shown in the "Mean" column. As an illustration, Statement 1 scored on average 4.83, Statement 2 scored on average 4.76, and so on. The overall evaluation of each statement's functionality is reflected in the mean score. Based on each statement's mean score, the "Qualitative Description" column offers a qualitative evaluation or description of it. Statements 1 to 4 in this instance were given the rating of "Excellent," signifying that they were highly regarded and delivered great work. This table suggests that the functionality of the device was positively assessed. The device was given an "Excellent" grade for statements 1 to 4, which refer to the equipment meeting expectations and carrying out duties efficiently.

Table 2. Acceptability of the device in terms of Applicability

B. Applicability	Mean	Qualitative Description
The device has a specific application	4.73	Excellent
The device accommodates the specific needs of its users.	4.83	Excellent
The device meets safety standards.	4.76	Excellent
Average Mean	4.77	Excellent

The table displays the respondents' perceptions, which assess the "Applicability" criterion based on three distinct assertions about how well-suited and adaptable the device is to various applications and user requirements. The average ratings or scores assigned to each statement are shown in the "Mean" column. As an illustration, Statement 1 obtained an average score of 4.73, Statement 2 an average score of 4.83, and Statement 3 an average score of 4.76. The total evaluation of the applicability of each statement is represented by the mean score. Based on each statement's mean score, the "Qualitative Description" column offers a qualitative evaluation or description of it. Statements 1 to 3 in this situation were both given the rating "Excellent," meaning that is indicated it was extraordinary and met or surpassed

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safety requirements. This table suggests that the device's applicability was given a favorable evaluation. According to Statement 1, the device has a specific application was given an "Excellent" rating, indicating that it is suitable for a specific function or purpose. Statement 2 emphasizes the device accommodates the specific needs of its usersreceived an "Excellent" grade, signifying that it is able to satisfy the wants and preferences of its users. The device's other criterions received excellent meaning it encompasses to the expected applicability of which excellent in all forms.

C. Durability	Mean	Qualitative Description
Resistance for deformation	4.73	Excellent
Quality of the design	4.67	Excellent
Endurance of the unit to high temperature	4.73	Excellent
Average Mean	4.71	Excellent

Table 3. Acceptability of the device in terms of Workability

The table evaluates the acceptability of the device in terms of workability, focusing on the availability of materials, expertise, and tools/machines for fabricating. Statement 1 indicates the result of 4.76 with a qualitative description of Excellent. This show that the availability of materials are easily purchased and can be ordered through online flatform stores. Statement 3 earned the second highest mean score of 4.63 which signifies that the making this device didn't make any problems due to availability of tools and machine need in making this prototype.

While Statement 2 earned the lowest mean score among the three statements but significantly rated Excellent in the qualitative description indicates that experts in this area of matter can be tap to assess the said prototype.In summary, Table 3 suggests that the device is highly acceptable in terms of workability. It benefits from the very good availability of materials, expertise, and tools/machines for fabricating. The top rank and "Very Good" descriptions across all categories indicate a high level of satisfaction with the device's workability. This is crucial for ensuring that the device can be effectively produced and maintained, contributing to its overall acceptability and functionality.

Table 4. Acceptability of the device in terms ofDurability

D. **Workability**	Mean	Qualitative Description
Availability of materials	4.76	Excellent
Availability of expertise	4.55	Excellent
Availability of tools and machines for fabricating	4.63	Excellent
Average Mean	4.64	Excellent

The table evaluates the "durability" criterion based on five distinct statements about the unit's ability to withstand high temperatures, resist deformation, and be well-designed. The average ratings or scores assigned to each statement are shown in the "Mean" column. As an illustration, Statement 1 to 3 both obtained an excellent result. These shows the device durability of each assertion is evaluated overall and represented by the mean score. Each statement is given a qualitative evaluation or description in the "Qualitative Description" column based on its mean score. In this instance. Statement 1 to 3 was given the rating of "Excellent," signifying that its design was of the highest calibre and that it was extraordinarily well regarded.The device's durability was determined to be favorable based on the information in this table. Statement 1 to 3, which focuses on withstands physical forces, including compression, tension, and torsion,the device's performance under various environmental stresses, the prototype behaves under repeated use over time, which may include abrasion resistance and wear testing, and device longevity and performance of the battery under typical usage conditions, including charge/discharge cycles, was given an "Excellent" rating, indicating that the device demonstrated best resilience and kept its form under a variety of circumstances.

Table 5. Acceptability of the device in terms ofSafety

E. Safety	Mean	Qualitative Description
1. Absence of sharp edges	4.25	Very Good
2. Absence of toxic materials	4.55	Very Good
3. Provision for protection	4.55	Very Good
Average Mean	4.45	Very Good

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Each statement's average score or rating is shown in the "Mean" column. As an illustration, Statement 1 obtained an average score of 4.25, Statement 2 an average score of 4.55, and Statement 3 an average score of 4.55. The overall evaluation of each statement's safety is represented by the mean score. All three of the statements in this instance were given the rating "Very Good," indicating that they were highly regarded and thought to have good safety precautions.

The data in this table led to the conclusion that the device's safety was adequate. This the absence of hazardous materials or any leaks in the device shows that the degree of safety during production was carefully taken into account to ensure that the user would not be harmed. The device's physical design identifies any moving elements, pinch points, or sharp edges that could be dangerous to use. This also shows the device's level of safety, allowing for effortless operation.

Summary

The ultimate goal of this research is to close the gap between conventional drying techniques and contemporary agricultural innovations, hence enhancing food security and corn growers' profitability. Future technological advancements in grain drying and storage solutions will be built upon the results of this study.

V. FINDINGS

Based on the comprehensive evaluation of the device the following key findings have emerged:

- The prototype received a great evaluation due to its outstanding functionality. This shows that the power management system is quite effective at detecting electrical problems and responding to both high and low voltage.
- This device is highly regarded for both home and business applications because to its adaptability and versatility. It meets user expectations, efficiently attends to particular demands, and offers a secure and hands-on learning environment for power management system knowledge.
- Users expressed satisfaction with the device's use as well as the availability of resources, including tools, materials, and assistance. Although the tool's capacity to offer worthwhile educational experiences scored marginally lower, there is still room for improvement.
- Users gave the item good marks for longevity because it showed a strong resilience to external variables, high temperatures, and deformation. The tool's lifespan is guaranteed by this sturdy framework, which qualifies it for extended usage.
- Users thought the prototype was great since it prioritized safety. The device puts user well-being first by removing sharp edges, staying away from hazardous chemicals, and adding safety features including sufficient protection and unambiguous instructions, which makes it appropriate for educational settings.

VI. CONCLUSIONS

In conclusion, Dual Source Micro-Controller Based Flatbed Dryer for Corn Grains has proven to be an effective and efficient solution for post-harvest drying, addressing key challenges in corn grain preservation. By utilizing dual energy sources (electricity and an alternative fuel source), the dryer ensures uninterrupted operation, making it suitable for areas with inconsistent power supply. The integration of a microcontroller-based system allows for precise temperature and humidity control, optimizing drying conditions to prevent over-drying or spoilage while maintaining grain quality. This automation reduces labor dependency and minimizes human error, leading to consistent and uniform drying results. Additionally, the flatbed design promotes even heat distribution, further enhancing drying efficiency. Farmers and agricultural users benefit from reduced post-harvest losses, improved grain shelf life, and energy savings due to the system's intelligent power management. Overall, this dryer demonstrates high effectiveness in preserving corn grains, offering a reliable, cost-effective, and sustainable drying solution for small to medium-scale farming operations. With further scalability and minor refinements, it has strong potential for widespread adoption in the agricultural sector.

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