International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 8, Issue 11, ISSN No. 2455-2143, Pages 53-59
Published Online March 2024 in IJEAST (http://www.ijeast.com)

DEVELOPMENT OF AN IOT-BASED DRYER FOR TIGER GRASS (THYSANOLAENA LATIFOLIA)

Ronnie B. Santelices
Faculty of College of Engineering and Architecture
Catanduanes State University
Philippines

Renz Pyron M. Coma, Jefferson Karl T. Dayawon, Chrisel I. Icawat
John Leve Q. Macato, Jinky T. Montarde
Graduates of College of Engineering and Architecture
Catanduanes State University
Philippines

Abstract— **Tiger Grass, scientifically known as Thysanolaena latifolia, is highly esteemed in several industries for its resemblance to bamboo and its dense growth patterns, particularly in the manufacturing of soft brooms. A crucial step in its production involves sun-drying the freshly harvested tiger grass, upon which the quality of the broom hinges. There have been challenges in obtaining grass panicles leading to compromises in the quality of products. On the hand tiger grass farming in Romblon has become a venture with support from the Department of Science and Technology (DOST). Understanding the need for modernization the Mayor of San Agustin initiated a project to establish a processing facility for grass. To tackle drying process inefficiencies, a dryer system based on the Internet of Things (IoT) has been proposed to enhance both efficiency and product quality. The study seeks to develop a ceramic air heater equipped with remote temperature control and monitoring capabilities for drying tiger grass, alongside a load cell sensor for measuring moisture content and weight. Analysis of data indicates that the ceramic air heater powered by alternating AC) effectively maintains temperatures during drying processes. Comparative studies demonstrate the advantages of automated drying over sun drying due to time savings and reliable outcomes. Assessments, on cost effectiveness underscore the benefits of drying tiger grass instead of soaked ones highlighting increased revenue potential and profitability. To sum up focusing on drying harvested grass first and incorporating automated drying technology is advised to enhance cost effectiveness and financial gains in the tiger grass sector. These results underscore the significance of embracing progress and making choices to enhance sustainability and profitability, in agricultural operation**s.

Keywords: **Tiger grass, Sun drying, Ceramic air heater, Temperature sensor, Load cell sensor**

I. INTRODUCTION

Tiger Grass (Thysanolaena latifolia) holds importance across different industries, particularly in soft broom manufacturing. It resembles bamboo in appearance and grows independently, forming dense clumps as a perennial grass. Its stems are commonly employed to wrap food, while its flowers are harvested for broom production. Soft broom making traces its origins back to the mid-1900s in the Municipality of Natonin, a 4th class municipality in the province of Mountain Province, Philippines, where tiger grass grew abundantly along the Pap-arong River located north of the barangay, initially satisfying local needs (Tiger Grass flourish in Natonin, Mountain Province).Additionally, C et al., (2020)explores the potential and advantageous applications of Tiger Grass as an alternative building insulation material, utilizing arrowroot starch as a binder, thus offering promising avenues for sustainable construction practices.

As demand grew, the community had to source tiger grass panicles from distant locations like Sablan, Benguet, leading to logistical challenges and compromised quality. Conversely, in Romblon, particularly in the municipalities of San Agustin and San Andres, tiger grass cultivation is extensive and commercialized due to its ease of growth and income potential (Fetalvero & Faminial, 2010). The Department of Science and Technology (DOST) in Romblon reports significant cultivation areas, particularly in

International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 8, Issue 11, ISSN No. 2455-2143, Pages 53-59
Published Online March 2024 in IJEAST (http://www.ijeast.com)

barangay Dona Juana, San Agustin, estimating substantial annual harvest values and engaging hundreds of farmers.

Recognizing the industry's potential and the necessity for modernization, the Mayor of San Agustin initiated a project for a common service facility to process tiger grass. Drying is one of the oldest preservation processes available to the mankind (Gladson et al., 2020). However, traditional drying methods for tiger grass pose challenges due to their lack of precision, labor-intensiveness, and susceptibility to environmental variations like humidity and temperature fluctuations. Hence, the development of an Internet of Things (IoT)-based dryer emerges as a solution to enhance efficiency, quality, and control in processing tiger grass. By integrating IoT technology, this study seeks to provide real-time monitoring and control capabilities, optimizing drying parameters and facilitating remote management to improve operational efficiency and productivity. Addressing the current challenge of reducing drying costs through effective energy management, including heat recovery and moisture extraction from the drying air, is a key focus(Chojnacka et al., 2021). Overall, the study aims to contribute to the advancement of agricultural processing methods and sustainable utilization of tiger grass resources.

The principal aim of this research is to develop a specialized Internet of Things (IoT)-based dryer system tailored specifically for processing Tiger Grass (Thysanolaena latifolia). This objective will be realized through several specific aims: firstly, the creation of a ceramic air heater utilizing alternating current (AC) as its power source for the efficient drying of tiger grass. Secondly, the incorporation of temperature control and monitoring functions employing a temperature sensor, with recorded readings displayed on an LCD module and managed by a microcontroller (Arduino Uno). Thirdly, the utilization of a load cell sensor alongside a timer mechanism to accurately measure the initial and final weights of tiger grass, enabling precise determination of its drying duration throughout the entire process. Fourthly, a comparative analysis between sun drying and the automated drying system will be conducted, evaluating key metrics such as time elapsed and weight changes. Finally, an assessment and comparison of the cost efficiency of drying between fresh and soaked tiger grass will be performed, considering factors like energy consumption, labor costs, and operational expenses. Through these comprehensive objectives, the study aims to advance the tiger grass processing industry, offering improved efficiency and sustainability while enhancing the economic prospects of communities engaged in its cultivation and utilization.

II. RESEARCH METHODOLOGY

The research design of the study involves a comparative experimental approach, wherein two different drying methods for tiger grass are evaluated and compared. Specifically, the study compares traditional sun drying and automated drying system. The variables such as drying time, weight changes, product quality, cost efficiency, and environmental impact are measured and compared between the two groups. The research design aims to systematically assess the effectiveness, efficiency, and feasibility of the proposed automated drying system in comparison to traditional sun drying methods, providing valuable insights into its potential benefits and drawbacks. The experiments were conducted at a laboratory facility within the College of Engineering and Architecture, equipped with necessary infrastructure and tools for conducting drying experiments, including a drying chamber, ceramic air heater, temperature sensor, load cell sensor, and data collection and analysis tools.A new approach to drying grains and eliminating moisture has been developed by Sh et al., (2016). This method involves receiving and managing the heat generated during the process, following principles outlined by thermodynamics equations.

The conceptual framework of this study revolves around the Input variables encompassing weather conditions, moisture content, energy consumption, and labor costs are considered pivotal factors influencing the drying process. The process entails the utilization of a ceramic air heater coupled with controlled temperature and monitoring systems to optimize drying conditions. Additionally, the measurement of weight using load cell sensors is integrated into the process to accurately gauge moisture content. Outputs of interest include the duration of the drying process, fluctuations in weight over time, and the resultant quality of the dried product. These outputs collectively serve as indicators of the efficiency and effectiveness of the drying system, providing insights into its performance and potential areas for improvement.

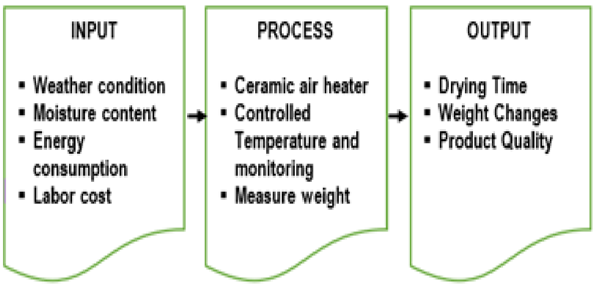

Figure 1: Conceptual Framework of Tiger Grass Dryer

Figure 2 depicts a block diagram outlining the sequential arrangement of electrical components in an automated drying system tailored for drying tiger grass. Commencing from the AC source, electrical power travels through a power supply unit tasked with adjusting voltage and current to meet the system's specifications. Subsequently, this power is directed to both the ceramic air heater fan and the exhaust fan, essential for the circulation of air within the drying chamber and maintaining adequate ventilation crucial

International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 8, Issue 11, ISSN No. 2455-2143, Pages 53-59
Published Online March 2024 in IJEAST (http://www.ijeast.com)

for facilitating an efficient drying process. Subsequently, the power supply energizes the microcontroller, specifically an Arduino Uno, which serves as the central control unit of the system. Upon activation, the microcontroller triggers the operation of various sensors, including the temperature sensor, smoke sensor, and load cell sensor, to monitor key parameters during the drying process. At the onset of the tiger grass drying process, temperature levels are continuously monitored and regulated by the system, facilitated by LCD module displays and a wireless control device employing ESP-32 technology. Upon completion of the drying process, a buzzer is activated to signal completion, alerting users. Additionally, real-time temperature readings are displayed on an LCD module for constant monitoring and adjustment as needed, providing a comprehensive overview of the drying operation. In their research, Mishra et al., (2023) embarked on designing and assessing an IoT-BC system aimed at remotely managing, alerting about potential hazards, and overseeing microclimate parameters such as relative humidity (RH), temperature, and air velocity, employing ESP-32 technology.

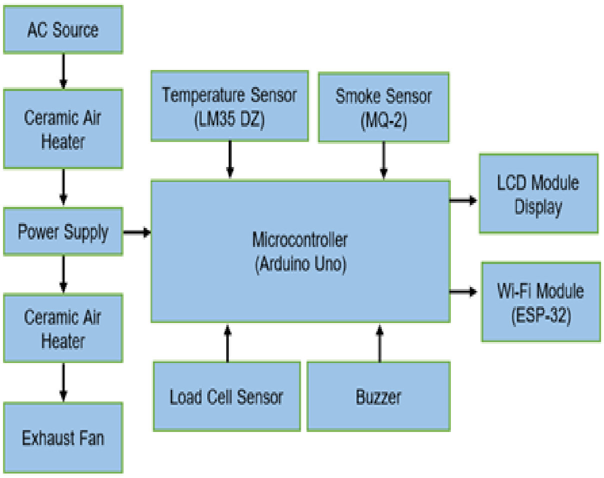

Figure 2: Block Diagram of Tiger Grass Dryer

Figure 3 illustrates the prototype of the tiger grass dryer alongside its system components, which include machine layers for uniform spreading of tiger grass, a power button for activation, an LCD module displaying the temperature gauge of the ceramic heating element, the ceramic heating element itself responsible for supplying heat, a calibration mechanism for adjusting heating requirements, a buzzer for overheating alerts, a yellow LED indicating drying completion, fan to function as an internal blower within the dryer for even temperature distribution similar to the study of Sarmiento (2022)and safety mechanisms for secure operation and power-off capabilities. These components collaborate to facilitate the efficient and effective drying of tiger grass. Additionally, the frontal perspective of the prototype showcases three tiers and a front panel made of basic sheets, within which various sensors such as temperature, smoke, buzzer, and load cell sensors are integrated. Furthermore, the chamber is equipped with an exhaust fan and a ceramic air heater fan to optimize the drying process.

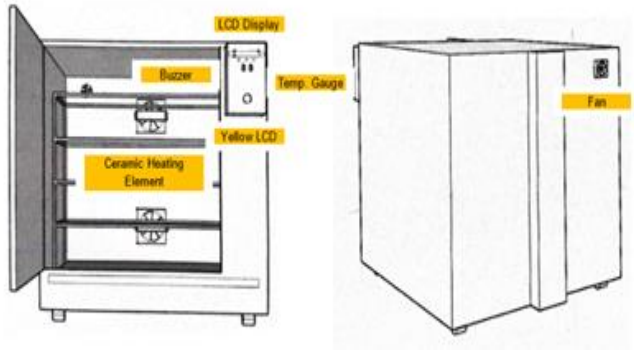

Figure 3: Prototype System Components

III. RESUTS AND DISCUSSION

When powered on, the ceramic air heater fan generates high levels of heat within the chamber, which is subsequently regulated by the exhaust fan to maintain optimal temperatures throughout. Utilizing the load cell sensor, the weight of the tiger grass inside the chamber is measured, aiding in the assessment of its quality. Temperature levels within the chamber are monitored by both a DS18B20 Temperature sensor and an MQ2 smoke sensor, which also identifies smoke particles suspended in the air. Upon reaching the desired weight, the device emits a buzzing sound, and in case of overheating beyond a predefined threshold or prolonged unattended operation, the system automatically shuts off, accompanied by continuous buzzing. Normal operation resumes once the temperature stabilizes, facilitated by the exhaust fan. The LCD display provides real-time feedback on the tiger grass's weight, temperature, and heat index within the chamber.

3.1. Ceramic air heater utilizing alternating current (AC) as its power source during drying of tiger grass

The utilization of an alternating current (AC)-powered ceramic air heater in the tiger grass drying process presents numerous benefits. AC power ensures a stable and consistent energy source, enabling the ceramic heater to maintain optimal temperatures within the drying chamber for uniform drying results. This reliability is essential for preventing uneven drying and preserving the quality of the tiger grass. Moreover, ceramic heaters are renowned for their efficiency and reliability in heat generation, reaching high temperatures quickly and distributing heat evenly throughout the chamber. With minimal maintenance requirements and a long lifespan, ceramic heaters contribute to reduced downtime and operating costs. The combination of an AC-powered ceramic air heater offers an effective and efficient solution for tiger grass drying, ensuring consistent outcomes while minimizing energy usage and operational complexities. The prototype underwent thorough testing, including assessments of its components, source code, and overall functionality. Researchers conducted sensor tests using provided source code and a trial involving 2000 grams of standardized-length Lasa to determine the optimal drying duration.

Table 1. Drying Characteristics of "Fresh" Variety Lasa Samples

No. of Samples	Initial Weight	Final Weight	Drying Time
1	2000g	1700g	3.05 hrs.
2	2000g	1600g	3.15 hrs.
3	2000g	1750g	3.00 hrs.
Average	2000g	1683g	3.07 hrs.

Table 1 summarizes the drying process results for tiger grass across three samples, detailing initial and final weights as well as drying durations. Sample 1 started at 2000 grams and ended at 1700 grams after 3 hours and 5 minutes, while Sample 2 saw a decrease from 2000 grams to 1600 grams over 3 hours and 15 minutes. In contrast, Sample 3 increased from 2000 grams to 1750 grams after 3 hours. These variations suggest differing drying characteristics influenced by factors like moisture content and environmental conditions. Averaging across samples, initial weight remains consistent at 2000 grams, with a final average weight of 1683 grams and an average drying time of approximately 3 hours and 7 minutes. Despite variations, the consistent weight loss pattern and effective drying duration indicate successful outcomes, emphasizing the need for meticulous monitoring and understanding of the drying process for consistent results.

Table 2. Drying Characteristics of "Soaked" Variety Lasa Samples

No. of Samples	Initial Weight	Final Weight	Drying Time
1	2000g	1000g	3.50 hrs.
2	2000g	950g	4.00 hrs.
3	2000g	1200g	3.57 hrs.
Average	2000g	1016g	3.55 hrs.

Table 2 outlines data regarding the drying process of tiger grass across three samples, detailing initial weight, final weight after drying, and drying duration. Sample 1 started at 2000 grams and ended at 1000 grams after 3 hours and 30 minutes, while Sample 2 decreased from 2000 grams to 950 grams over 4 hours. Conversely, Sample 3, also starting at 2000 grams, increased to 1200 grams after 3 hours and 57 minutes. Averaging across samples, initial weight remained at 2000 grams, with an average final weight of 1016 grams and an average drying time of approximately 3 hours and 55 minutes. These results highlight considerable variations in both final weight and drying duration among the samples, underlining the necessity of comprehensively understanding and optimizing drying conditions for consistent and favorable outcomes.

3.2. Integrate temperature control and monitoring functionalities using controlled temperature sensor, and LCD module display and a microcontroller

Researchers calculated how much "Fresh" and "Soaked" Lasa, on average, was dried per session. Each session used 2000 grams of Lasa, with three samples of each variety, totaling six samples. They determined the average amount dried per session by looking at the starting and ending temperatures, along with the final weight of the samples.

Table 3. Drying of “fresh” tiger grass with respect to temperature

Sample No.	Initial Weight	Temp.	Final Weight	Temp.
1	2000g	29.0°C	1700g	40.0°C
2	2000g	29.5°C	1600g	43.0°C
3	2000g	29.5°C	1750g	43.0°C
Average	2000g	29.3°C	1683g	42.0°C

Table 3 provides data on the drying process of Lasa samples, presenting initial weight, temperature, final weight, and temperature for each sample. Sample 1 began at 2000 grams and ended at 1700 grams, with temperatures recorded at 29.0°C and 40.0°C respectively. Sample 2 started with the same initial weight, decreasing to 1600 grams, with temperatures recorded at 29.5°C and 43.0°C. Similarly, Sample 3 began at 2000 grams, concluding at 1750 grams, with temperatures recorded at 29.5°C and 43.0°C. Averaging across samples, initial weight remained at 2000 grams, with an average initial temperature of 29.3°C, final weight averaging at 1683 grams, and an average final temperature of 42.0°C. These findings showcase variations in both initial and final weights and temperatures among the samples, shedding light on the drying characteristics of the investigated Lasa samples.

International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 8, Issue 11, ISSN No. 2455-2143, Pages 53-59
Published Online March 2024 in IJEAST (http://www.ijeast.com)

Table 4. Drying of "soaked" tiger grass with respect to temperature

Sample No.	Initial Weight	Temp.	Final Weight	Temp.
1	2000g	27.0°C	1000g	40.0°C
2	2000g	27.0°C	950g	41.0°C
3	2000g	28.0°C	1200g	43.0°C
Average	2000g	27.3°C	1016g	41.3°C

Table 4 presents the results of drying experiments conducted on soaked tiger grass, examining the relationship between temperature and mass change. Three samples of tiger grass, each initially weighing 2000 grams, were subjected to varying temperatures during the drying process. The initial temperatures ranged from 27.0°C to 28.0°C, while the final temperatures ranged from 40.0°C to 43.0°C. The corresponding final weights varied, with the lowest being 950 grams and the highest 1200 grams. The average initial temperature across all samples was 27.3°C, and the average final temperature was 41.3°C, resulting in an average final weight of 1016 grams. These findings suggest that the drying process of soaked tiger grass is influenced by temperature, with higher temperatures generally leading to greater mass loss.

3.3. Comparative analysis of the drying duration between sun drying and the automated drying system, considering both time elapsed and weight changes as key metrics for evaluation

Table 5. Comparative analysis of drying methods for "fresh" Tiger Grass

Tiger Grass Weight	Sun Drying		Automated Drying	
	Time	Final Weight	Time	Final Weight
1000g	48.0 hrs.	790g	2.15 hrs.	800g
2000g	48.0 hrs.	1578g	3.07 hrs.	1683g

Table 5 presents a comparative analysis of drying methods for "fresh" tiger grass, highlighting the efficiency and outcomes of sun drying versus automated drying processes. When starting with 1000g of tiger grass, sun drying required 48.0 hours to reduce its weight to 790g, while automated drying achieved a comparable weight reduction in just 2.15 hours, resulting in a final weight of 800g. Similarly, for a larger initial quantity of 2000g, sun drying took 48.0 hours to reach a final weight of 1578g, whereas automated drying accomplished a similar weight reduction in only 3.07 hours, resulting in a final weight of 1683g. These findings emphasize the rapidity and scalability of automated drying, offering quicker processing times without compromising the final product's weight. Additionally, automated drying ensures consistent and reliable results across varying quantities of tiger grass, indicating significant advantages over traditional sun drying methods. However, further considerations such as cost-effectiveness, energy consumption, and product quality impacts should be evaluated to determine the most suitable drying method for specific applications and contexts.

Table 6. Comparative analysis of drying Methods for "soaked" Tiger Grass

Tiger Grass Weight	Sun Drying		Automated Drying	
	Time	Final Weight	Time	Final Weight
1000g	72.0 hrs.	470g	3.30 hrs.	500g
2000g	72.0 hrs.	990g	3.55 hrs.	1016g

Table 6 presents a comparative analysis of drying methods for "soaked" tiger grass, delineating the effectiveness of sun drying versus automated drying processes. For an initial quantity of 1000g of soaked tiger grass, sun drying required an extended period of 72.0 hours to reduce its weight to 470g, while automated drying achieved a similar reduction in a significantly shorter duration of 3.30 hours, resulting in a final weight of 500g. This substantial discrepancy in drying time highlights the efficiency of automated drying, particularly in expediting the drying process for soaked tiger grass. Moreover, with a larger initial quantity of 2000g, sun drying and automated drying still maintained similar trends. Sun drying took 72.0 hours to achieve a final weight of 990g, whereas automated drying accomplished a similar weight reduction in 3.55 hours, resulting in a final weight of 1016g. This comparison emphasizes the consistent efficiency of automated drying across different quantities of soaked tiger grass, offering significant time savings while ensuring comparable final weights.

3.4. Evaluation and comparison of the cost efficiency of drying between fresh and soaked tiger grass, considering factors such as energy consumption, labor costs, and operational expenses

When evaluating the cost efficiency of drying, fresh tiger grass typically requires less time and energy compared to soaked tiger grass due to its lower moisture content, resulting in reduced energy consumption and labor costs. Additionally, operational expenses may vary as fresh tiger grass often undergoes shorter drying periods, potentially leading to higher productivity and throughput compared to soaked tiger grass, thus affecting overall cost efficiency differently. According to Mr. Benjamin Rima, a farmer from Tariwara, Pandan, Catanduanes, during an interview, small-sized Lasa sells for P100, with daily earnings of P343.67 from selling fresh Lasa and P247 from soaked Lasa. Over 30 days, total income from selling fresh Lasa amounts to P10,310.1, while it takes 40 days to earn P9,880 from soaked Lasa. Abaca farmers can make a profit of P2,744.85 from fresh Lasa and P2,314.75 from soaked Lasa, resulting in a return on investment of 36.28% for fresh Lasa over 30 days and 30.59% for soaked Lasa over 40 days.

Table 7. Cost Efficiency Comparison between Drying Fresh and Soaked Tiger Grass

Activity / Expenses	**Fresh Tigers grass**	**Soaked Tiger grass**
Drying Time	12.28 hrs. (4 sessions)	11.45 hrs. (3 sessions)
Power Consumption	4.478 kWh	4.219 kWh
Electricity Rate per day	Php 56.33	Php 53.07
Revenue per day	Php 343.67	Php 247.00
Total Revenue	Php 10,310.10	Php 9,880.00
Profit	Php 2,744.85	Php 2,314.75
Return of Investment	36.28%	30.59%

Table 7 presents a comprehensive comparison of cost efficiency between drying fresh and soaked tiger grass, highlighting key activities and expenses associated with each process. For fresh tiger grass, drying time spans 12.28 hours across four sessions, resulting in a higher power consumption of 4.478 kWh compared to soaked tiger grass, which requires 11.45 hours over three sessions with a slightly lower power consumption of 4.219 kWh. Despite the higher electricity rate per day for fresh tiger grass (Php 56.33) compared to soaked tiger grass (Php 53.07), the revenue generated per day is significantly higher for fresh tiger grass (Php 343.67) than for soaked tiger grass (Php 247.00). Consequently, the total revenue and profit for drying fresh tiger grass are also higher, amounting to Php 10,310.10 and Php 2,744.85, respectively, compared to Php 9,880.00 and Php 2,314.75 for soaked tiger grass. Additionally, the return on investment is notably greater for fresh tiger grass at 36.28% compared to 30.59% for soaked tiger grass, indicating a higher level of cost efficiency in the drying process for fresh tiger grass.

IV. CONCLUSIONS AND RECOMMENDATIONS

Ensuring the quality of dried tiger grass is essential for sustaining broom production standards and supporting livelihood opportunities for upland farmers, given the rising demand for brooms made from tiger grass. To achieve this, the present study has introduced a smart IoT-based drying system that integrates sensors, actuators, and associated drying equipment. In conclusion, the comprehensive analysis of drying methods for both fresh and soaked tiger grass reveals nuanced insights into their respective cost efficiencies and economic viability. While fresh tiger grass exhibits slightly longer drying times and higher energy consumption per session, its significantly higher revenue generation and profitability, as evidenced by Table 7, underscore its superior economic potential over soaked tiger grass. The higher return on investment and greater overall profitability of drying fresh tiger grass emphasize its attractiveness as a more lucrative option for farmers and businesses in the tiger grass industry. Moreover, the data underscores the importance of considering broader economic implications beyond just drying times and energy consumption, highlighting the need for a holistic approach to decision-making in agricultural drying processes.

Based on the findings presented in the analysis, it is recommended that farmers and businesses in the tiger grass industry prioritize the drying of fresh tiger grass over soaked tiger grass to maximize cost efficiency and economic returns. Implementing automated drying systems powered by stable alternating current (AC) sources, as discussed in the provided context, can further enhance efficiency and reliability in the drying process. Additionally, continual monitoring and optimization of drying conditions, including temperature control and airflow management, are crucial to ensuring consistent and desirable outcomes. By adopting these recommendations, stakeholders can capitalize on the economic advantages offered by drying fresh tiger grass, ultimately optimizing their operations and driving long-term sustainability and profitability in the tiger grass industry.

V. REFERENCES

[1]. Efendi, A., Nugraha, A., &Baharta, R. (2019). Manufacturing of electrical dryer machine for food and fruit products. IOP Conference Series: Materials Science and Engineering, 692(1). https://doi.org/10.1088/1757-899X/692/1/012006

[2]. Fetalvero, E. G., &Faminial, T. T. (2010). Student and Teacher Partnership in the Study of Tiger Grass Industry in Marigondon Norte, San Andres, Romblon: Lessons for Novice Researchers 1. 149–157.

[3]. Gladson, J. N., Dhinesh, Dinesh, &Elango. (2020). Design and fabrication of Automated Coir Dryer. International Journal of Scientific Research and Engineering Development, 3(3), 828–836. www.ijsred.com

[4]. Janjai, S., &Bala, B. K. (2012). Solar Drying Technology. Food Engineering Reviews, 4(1), 16–54. https://doi.org/10.1007/s12393-011-9044-6

[5]. C, Val, J., & Val, J. (2020). Preliminary Investigation on Tiger Grass Pollen as an Alternative Insulation Board Material. http://www.brainitiativesph.com/uploads/7/7/6/776 44974/ramos_rp_edi_26oct.pdf

[6]. Chojnacka, K., Mikula, K., Izydorczyk, G., Skrzypczak, D., Witek-Krowiak, A., Moustakas,

K., Ludwig, W., & Kułażyński, M. (2021). Improvements in drying technologies - Efficient solutions for cleaner production with higher energy efficiency and reduced emission. Journal of Cleaner Production, 320(January). https://doi.org/10.1016/j.jclepro.2021.128706

[7]. Gladson, J. N., Dhinesh, Dinesh, & Elango. (2020). Design and fabrication of Automated Coir Dryer. International Journal of Scientific Research and Engineering Development, 3(3), 828–836. www.ijsred.com

[8]. Mishra, N., Jain, S. K., Agrawal, N., Jain, N. K., Wadhawan, N., & Panwar, N. L. (2023). Development of drying system by using internet of things for food quality monitoring and controlling. Energy Nexus, 11(February), 100219. https://doi.org/10.1016/j.nexus.2023.100219

[9]. Sarmiento, J. (2022). Design and development of a Solar Power-Based Cocos nucifera Dryer. 3(3), 12–20.

[10]. Sh, A., Atyhanov, A. K., Sagyndykova, A. Z., Beloev, H., & Daskalov, P. (2016). Abstract. 22(2), 318–323.

[11]. No Title. (n.d.). https://saad.da.gov.ph/2022/01/tiger-grass-flourish-in-natonin-mountain-province

[12]. Singh, G. (2012). Sequence Control of Grain Dryer Machine using PLC. IOSR Journal of Electrical and Electronics Engineering, 3(6), 34–40. https://doi.org/10.9790/1676-0363440

[13]. Smelik, V. A., Perekopskiy, A. N., Dobrinov, A. V., &Chugunov, S. V. (2021). Study of the efficiency of drying grass seeds for forage crops on a rotary dryer. E3S Web of Conferences, 262. https://doi.org/10.1051/e3sconf/202126201037

[14]. Waewsak, J., Chindaruksa, S., &Punlek, C. (2006). A mathematical modeling study of hot air drying for some agricultural products. Thammasat International Journal of Science and Technology, 11(1), 14–20.

[15]. Wang, G., Wu, W., Xu, W., Xu, Y., Zhang, Y., & Fu, D. (2022). Exergy analysis of an electric grain drying system with internal circulation of the drying medium of corn. International Journal of Exergy, 37(1), 102–120. https://doi.org/10.1504/ijex.2022.120127