PERFORMANCE EVALUATION OF PORTABLE ONION STORAGE SYSTEM

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ABSTRACT

This study utilized a longitudinal design to assess the performance of a semi-automatic onion storage system over a 160-day period, from May to October. The aim was to evaluate various aspects of onion preservation, including physiological weight loss, sprouting, bulb rot, marketability, power consumption, and environmental conditions. The prototype, which can store onions for up to 160 days and effectively fulfills its intended purpose as well as the needs of onion farmers regarding storage, was successfully created, built, and extended the shelf life of onions by the researcher. The evaluation's tests proved the prototype's excellent ability to extend onions' shelf lives, demonstrating remarkable technical developments that provide growers of onions the choice between automatic and manual operating modes. Moreover, the integration of automated dehumidifier control and solar energy usage makes the system sustainable and effective while significantly reducing energy consumption. The comparative analysis showed that the created machine was more efficient than the untreated fan. Based on these findings, the system is practical for improving onion storage, thereby transforming current cold storage practices.

Keywords: *portable onion storage system, onion farmers, onion, prototype, automated*

INTRODUCTION

Onions are a crucial crop valued for their flavor, pungency, and culinary versatility (Lawal et al., 2019). Traditionally grown for both domestic consumption and export, global onion production has seen a significant increase, rising by 51.6% from 33 million tons in 2003 to 64 million tons in 2007 (Food and Agriculture Organization of the United Nations, 2012). In the Philippines, nearly 22 provinces contribute to onion production, with Regions III, I, II, VI, and IV-B being major producers of four onion varieties: Red Creole, Yellow, Granex, and Shallots/Multipliers (Department of Agriculture – Philippine Rural Project, 2021). Production of onion in the second quarter of 2023 was recorded at 84.90 thousand metric tons. This was 3.4 percent higher than the previous year's same quarter output of 82.08 thousand metric tons. Among the regions, MIMAROPA Region was the top producer of onion during the quarter with a production of 46.94 thousand metric tons or 55.3 percent share to the total (Philippine Statistics Authority, 2023).

Despite its value, managing onion supply has become increasingly difficult. Challenges include natural disasters, declining farming enthusiasm, disorganized commodity movement, and post-production delays (Calicia & Cabayanan, 2018). Effective storage is crucial to extend shelf life and minimize quality and quantity losses. Although onion bulbs act as natural food reserves, they are susceptible to damage from soil-borne pathogens, affecting growth and sprouting. Ideal storage conditions require a temperature of 25°C - 30°C and relative humidity of 65% - 70%. Inefficient pre- and post-harvest management, poor storage environments, and unpredictable climatic conditions contribute to storage losses in tropical regions, which can range from 30% to 40% (Tripathi & Lawande, 2019).

To address these challenges, various storage solutions have been explored. Cold storage facilities effectively prolong onion shelf life but are expensive and inaccessible for many farmers. This has driven the development of cost-effective and energy-efficient alternatives. Recent research has investigated ambient and controlled temperature storage systems with natural ventilation. For example, Shankar, Thirupathi, and Venugopal (2017) described a farm ventilated storage system using wooden poles and dried coconut thatch for roofing, providing natural ventilation. Falayi and Yusuf (2014) designed a modified wooden storage structure in Nigeria, optimized for wind direction and ambient conditions. In the Philippines, the Department of Agriculture introduced non-refrigerated storage systems in 2013, including the Hanger Ambient Storage (HAS) and High-Temperature Storage (HTS). The HAS features a two-story structure with a wooden slat floor and steel screen walls for optimal air circulation (Idago et al., 2015). The HTS is a tunnel-type structure designed for high-temperature storage. Both systems can extend onion storage life but are limited to approximately three months.

San Jose in Occidental Mindoro is a major contributor to the province's onion production. However, many local farmers, who are small to medium-scale operators, lack access to expensive cold storage facilities. Consequently, they often sell onions immediately after harvest, limiting their profit potential. The main objective of the study is to evaluate the effectiveness of a semi-automatic storage system for onions by examining its impact on physiological weight loss, sprouting, bulb rot, marketability, power consumption, and environmental conditions over a 160-day period. The study aims to identify key factors influencing onion preservation and propose improvements for optimizing storage conditions to extend shelf life and minimize losses.

MATERIALS AND METHODS

Research Design

This study utilized a longitudinal design to assess the performance of a semi-automatic onion storage system over a 160-day period, from May to October. The aim was to evaluate various aspects of onion preservation, including physiological weight loss, sprouting, bulb rot, marketability, power consumption, and environmental conditions.

Data Collection

Data collection systematically monitored key aspects of onion storage to assess the semi-automatic system's performance. Weekly physiological weight loss was tracked using a digital scale, with losses calculated as a percentage of the initial weight. Sprouting was measured bi-weekly by weighing sprouted bulbs and calculating their percentage relative to total weight. Bulb rot was evaluated every two weeks, with rotting bulbs weighed and expressed as a percentage of the initial weight. Monthly assessments of marketable bulbs determined the weight of onions suitable for sale, and marketability was calculated as a percentage. Power consumption was documented monthly, tracking electricity usage by fans, dehumidifiers, and the system overall. Temperature and humidity were recorded three times daily (3 am, 12 pm, 9 pm) using data loggers to monitor fluctuations and trends. This comprehensive approach ensured accurate evaluation of the storage system's effectiveness in preserving onion quality.

Data Analysis

Data analysis evaluated the performance of the semi-automatic onion storage system and its impact on preservation factors. Descriptive statistics, including means, standard deviations, and percentages, summarized physiological weight loss, sprouting, bulb rot, marketability, power consumption, and environmental conditions. Weekly trends in physiological weight loss were plotted to identify patterns and fluctuations, while sprouting and bulb rot progression were correlated with storage conditions. Monthly marketability data tracked changes in the weight of marketable onions. Power consumption was analyzed for energy efficiency and its relation to environmental factors. Temperature and humidity trends were assessed for their effects on preservation. A comparative analysis against benchmarks and previous research highlighted the system's effectiveness and areas for improvement.

RESULTS

Physiological loss

The physiological loss in weight of onions shows a general increasing trend from May to October, reaching a peak in August before showing some reduction towards the end of the period. The total loss of 38.25 kg, which translates to 18.21% of the total weight, highlights a significant loss over the 160 days, suggesting potential issues related to storage conditions, handling, or intrinsic physiological factors (Table 1).

Table 1. Physiological loss in weight in 160 days (May-October).

WEEK	PHYSIOLOGICAL LOSS IN WEIGHT (KG)	PERCENTAGE (%)
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	1.45	0.69
6	4.20	2.00
8	4.10	1.95
10	4.40	2.09
12	4.30	2.04
14	5.20	2.47
16	4.10	1.95
18	3.50	1.66
20	4.90	2.33
22	2.10	1.00
Total	38.25	18.21

Sprouted bulbs

The result shows a gradual increase in the weight of sprouted bulbs from May to October, peaking in August at 0.5 kg and lowest in May at 0 kg. No sprouted bulbs were seen in May and June. This suggests stored onions began growing over time. The total weight of sprouted bulbs over five months was 1.9 kg, about 0.94% of the total. This small percentage indicates weight loss due to sprouting during storage, highlighting the need for monitoring to maintain product quality and minimize losses.

Table 2. Percentage of sprouted bulbs in 160 days (May-October).

WEEK	SPROUTED BULB (KG)	PERCENTAGE (%)
1	0.0	0.00
2	0.0	0.00
3	0.0	0.00
4	0.0	0.00
6	0.0	0.00
8	0.0	0.00
10	0.5	0.23
12	0.4	0.19
14	0.0	0.00
16	0.3	0.14
18	0.3	0.19
20	0.1	0.05
22	0.3	0.14
Total	1.9	0.94

Bulb rot and Marktable Bulb

The results show the onion decay during storage. The highest rot, 2.90 kg, was in September. The total rotten bulb for five (5) months was 22.35 kg, accounting to 10.64% of the initial weight. It was observed that no rotten bulb was observed in May, suggesting favorable conditions. A sudden increased was observed in July with 2.40 kg (1.14% of initial weight). The highest weight of rotten bulb was collected during September and may be attributed to the decrease in humidity during the rainy season. Furthermore, in May, 210 kg was initially placed in the developed onion storage. After six months of storage, only 147.50 kg of onion were considered as marketable accounting to 70.24% of the initial weight. The decreased was likely due to natural weight loss influenced by factors like temperature and humidity. The study suggests operational or environmental factors impacted onion quality, with increasing weight loss and rotting over time (Table 3).

Table 3. Percentage of bulb rot and marketable bulbs in 160 days (May-October).

Week	BULB ROT		MARKETABLE BULBS	
	Weight (kg)	Percentage (%)	Weight (kg)	Percentage (%)
1	0.00	0.00	210.00	100.00
2	0.60	0.28	209.40	99.71
3	0.90	0.42	208.50	99.29
4	1.05	0.50	206.00	98.10
6	2.30	1.09	199.40	94.95
8	2.00	0.95	193.00	91.90
10	2.40	1.14	185.50	88.33
12	2.00	0.95	178.70	85.10
14	1.30	0.61	172.00	81.90
16	2.20	1.14	165.20	78.67
18	2.20	1.05	159.00	75.71
20	2.90	1.38	152.10	72.43
22	2.50	1.19	147.50	70.24
Total	22.35	10.64	147.50	70.24

Power consumption

Results show power consumption from May to October, the including fan and dehumidifier usage, and electricity bills. The kilowatt data indicates energy efficiency, crucial for comparing to traditional cold storage. The total power consumption is 671 kW.; the fluctuations in fan and dehumidifier usage and bills show monthly variations, influenced by weather and operational needs (Table 4).

Table 4. Power consumption during the 6-month storage period.

MONTH	FAN CONSUMPTION (KW)	DEHUMIDIFIER (KW)	ELECTRICITY BILL (KW)
May	50	60	110
June	60	80	140
July	68	65	133
August	53	67	120
September	60	70	130
October	18	20	38
Total	309	362	671

Temperature and humidity level

Result shows the temperature and humidity changes over 160 days, the key for onion storage. These factors are crucial for regulating the system effectively, guiding adjustments based on weather. The monitoring was done every 3 am, 12 pm, and 9 pm to capture the daily trends for diverse data analysis. The weather, particularly in wet seasons, affects power consumption. The humidity decreases with rising temperature and vice versa. The high humidity (peaking at 87%) can mislead due to equipment issues. Unstable conditions affect system power use, potentially compromising efficiency. Considering environmental factors in system design ensures optimal performance, preserving onions effectively (Figure 1).

(a) (b)

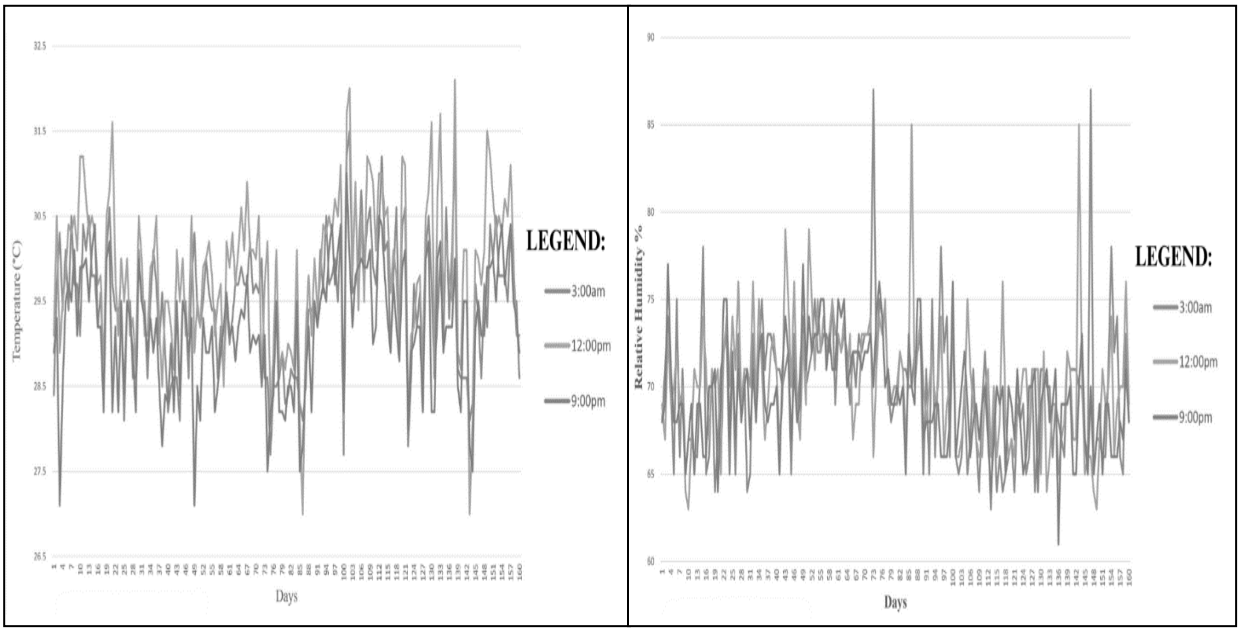

Figure 1. Monitoring of (a) temperature and (b) humidity in the developed onion storage

DISCUSSION

The data presented highlights the physiological weight loss in onions over 160 days, offering insights into the dynamics of dehydration throughout the storage period. This aligns with findings by Lawal et al. (2019), emphasizing the significance of understanding weight reduction patterns for effective agricultural planning. The study also underscores the importance of monitoring sprouting, as indicated by the work of Calicia & Cabayanan (2018), to mitigate losses and maintain product quality. Additionally, observations on onion decay, supported by the research of Kiran et al. (2024) and Falayi & Yusuf (2014), emphasize the necessity of implementing appropriate storage and handling practices to minimize spoilage.
Moreover, the study clarify the relationship between environmental factors and onion storage, echoing the findings of the Food and Agriculture Organization of the United Nations (2012) considering various conditions affect the quality, shelf life, and marketability of onions. These factors are crucial in ensuring that onions remain in good condition during storage, preserving their quality and reducing losses due to spoilage. The fluctuation in temperature and humidity levels, as discussed by Tripathi & Lawande (2019), underscores their critical role in influencing power consumption and ultimately the efficiency of storage systems. By considering such environmental factors, as recommended by Idago et al. (2015), onion storage systems can be optimized for enhanced reliability and effectiveness, thereby improving onion preservation and minimizing losses.

Idago et al. (2015) highlight the significance of physiological weight loss in onion storage. Dehydration affects quality and yield, urging farmers to manage crops effectively. Their study underscores the importance of understanding and quantifying these losses for optimizing production and reducing post-harvest losses.

The presence of sprouted bulbs in stored onions, as observed in the study, aligns with Naqash et al. (2021) findings, indicating a progression in onion physiology during storage. Monitoring sprouting trends is crucial for onion management to prevent quality deterioration and losses. Table 2 shows the percentage of sprouted bulbs in 160 days.

Isma'ila et al. (2017) highlight bulb rot's significant impact on onion storage, leading to economic losses. They likely explore its causes like fungal infections and environmental factors. Understanding these mechanisms is key for farmers to implement preventive measures such as proper storage and fungicide use, ensuring crop protection and market value preservation. Marketable bulbs play a crucial role in the onion industry, representing the subset of bulbs deemed suitable for sale and consumption. Eriballo et al. (2021) explore the significance of marketable bulbs in the onion industry, focusing on factors like size, shape, color, and quality. Understanding these factors helps optimize cultivation and post-harvest practices to meet market standards, benefiting both producers and consumers. Table 4 shows the result of the marketable analysis of stored onion after 160 days.

The study on onion storage power consumption, echoing SEforAll (2018), emphasizes energy efficiency's pivotal role in agriculture. The study underscores the importance of optimizing energy efficiency in storage facilitie. This aligns with global efforts for sustainable energy practices, advocating tailored strategies to minimize power consumption while maintaining effective storage conditions. Table 5 shows the power consumed during the storage period.

The study by Kelyaum et al. (2019) provides valuable insights into the intricate relationship between temperature and humidity in storage environments, particularly concerning onion preservation. Understanding these dynamics is crucial for maintaining optimal conditions that prolong onion shelf life and minimize spoilage. By examining the findings of Kelyum et al. (2019), the variations in temperature and humidity levels impact the efficacy of storage systems, influencing factors such as power consumption and overall efficiency. Incorporating these insights into the design and operation of onion storage facilities can ensure better control over environmental conditions, leading to improved preservation outcomes and reduced losses.

CONCLUSION

The researchers develop an alternative storage for onion by using semi-automatic functions to extend the shelf life of onions. The three key elements make up this new approach: a reliable power backup system, a powerful dehumidifier with automated input/output features, and an advanced primary control panel for the motor. The system provides improved operating efficiency and offers a workable answer for extending the shelf life of stored onions by smoothly integrating these components.

Researchers meticulously prepared an operation manual for users, which offered comprehensive guidance on operating the prototype. Users can understand and implement the system through this resource, improving its functionality and efficiency.

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