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Effects of Different Variables on Weight Loss of Onions in Microclimate Structure

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Abstract

An onion bulb storage structure with controlled mechanisms was designed and constructed in Dadin-kowa, Gombe State, Nigeria to reduced post-harvest losses by controlling temperature and relative humidity over a period of 60 days .The structure was made of mild steel of 0.4m for strength and durability, while the inner wall was made of MFB wood 18mm for insulation. Extractor fans and heating bulbs were used for temperature and relative humidity control and also for ventilation, while Arduino Uno and micro controller were used for automated control. Three compartment with different temperature and relative humidity in sealed storage compartments were studied presenting a novel approach to onion storage. Temperature at three levels (25°C, 30°C, and 35°C), three relative humidity levels (60%, 65%, and 70%), and a 60 days' time frame with an interval of seven days are considered, resulting in a set of 54 treatments . The experiment was carried out as a factorial in a completely randomised design. Key findings revealed temperature and time had significant effects on weight loss. The interaction between temperature and time showed a consistent increase in weight loss, emphasizing the importance of managing these factors for prolonged storage. Internal and external temperature, relative humidity within and outside the structure were monitored and the physiological weight loss were recorded every at seven days interval. Data obtained were subjected to ANOVA to compare the mean difference. Onions stored in compartment 1with 25ºC and 65% relative humidity combination had a lowest physiological loss in weight of 32%, while compartment 3 with 35ºC and 70% relative humidity combination had 70% of highest loss in weight .This study concluded that the design needs ventilation and roofing material that would aid significantly in the control of both temperature and relative humidity within the storage, hence the structure has been able to reduce internal temperature to minimal level near to suit onion storage.

Keywords: *Onions, Relative Humidity, Temperature, Weight Loss, Control*

1.0 Introduction

1.1 The Onion (Allium cepa) which is called a bulb onion, common onion and garden onion are widely used and highly versatile foods that are integral to many cuisines around the World. They are a rich source of nutrients and provide a range of health benefits, including reducing the risk of heart disease and certain cancers (Arung *et al.*, 2011*)*. It is the most widely cultivated species of the genus Allium because of its pungent bulbs and flavourful leaves. Traditionally, onions have been stored in cool, dark, and well ventilated place, such as underground cellars or sheds. These storage methods, are not always effective in preserving the onions (Karanja *et al*., 2020) additionally, these traditional methods do not take into account the specific microclimate conditions that are optimal for preserving onions. Modern storage methods, such as refrigeration and controlled atmosphere storage, have been developed to extend the shelf life of onions. However, these methods can be costly and may not be suitable for small scale farmers or those in developing countries (Bukar et al., 2023). Onion can be stored at ^{0}C and at 70-80% Relative Humidity (RH) for up to 8-9 months. At higher temperatures the storage life progressively decreases (Tripathi and Lawande, 2019). Different types of storage structures is used for onions in different parts of the country. Most of these structures lack proper ventilation and have more loading height resulting in higher storage losses (Roy and Chakrabati, 2002). (Biswas et al., 2010) reported that 46% to 56% bulb storage losses are found under different kinds of storage structures. Onion is always in abundance in Nigeria during dry season, during this bulk production period, onion farmers either sell their produce at throw out price in panic of high storage loss or store for a few days using traditional methods under ambient . Lord Abbey et al, (2000) reported high rate of physiological weight loss in the first four weeks under naturally ventilated structure. Such results vary with the type of cultivar and physical property of the environment under study. In order to guarantee the availability of onion in the market, in good quality and stabilize price from one harvesting season to the other, calls for effective storage. Despite the importance of onions and the need for proper storage, there is lack of comprehensive research on the various problems associated with onion storage and the factors that contribute to these problems, the storage system is still largely primitive in Nigeria, where the bulk of onions storage takes place in traditional structures and its concentration in the Northern part of the country where the onions are grown in large quantities (Fumen *et al., 2017).* Designing an effective microclimate structure for onion storage is important for preserving quality and preventing spoilage. The storage structure can be strategically designed to exert control over key environmental factors, including temperature, relative humidity, and air circulation. This ensures that optimal conditions are maintained, slowing down sprouting, inhibiting rotting, and minimizing other factors that could degrade the quality of onions. The control of these environmental variables contributes significantly to extending the shelf life of onions and enhancing overall storage efficiency. By controlling these parameters, the microclimate structure aims to create an optimal condition for preserving onions while also being cost-effective and accessible to a wide range of growers. The implications of this research could lead to improved onion storage practices and increase food security in the country.

2.0 Materials and method

The experiment was carried out at the Department of Agricultural Technology Laboratory, The Federal College of Horticultural Technology, Dadin-Kowa, Gombe State. The Experiment took place between May to December. The study area is characterized as tropical, 643m above sea level, with an annual temperature range of 24^o-48^o, and estimated annual rainfall range from 760-1110mm (Audu, 2014). Onion is one of the major crop crops grown in the area in commercial quantity, with an estimated production of 25 tons per hectare. Onion is grown in the rainy season from May to September, and in the dry season using irrigation from November to April. Varieties grown in the area are mostly local, they include Yar Romi,Yar Gaidam,Fitsarin Godiya,Mai Faranti,Zobo and some adopted varieties like Red Creole, Sweet Yellow and Violet De Galma.

2.1 Materials for developing the structure

The materials used for developing the storage structure include Arduino Uno ,micro controller, DHT1 sensors, Extractor fans, heating bulb, LCD 16*2, Programmer module, Wood, Mild steel, Solar panels, Battery and Lagging materials

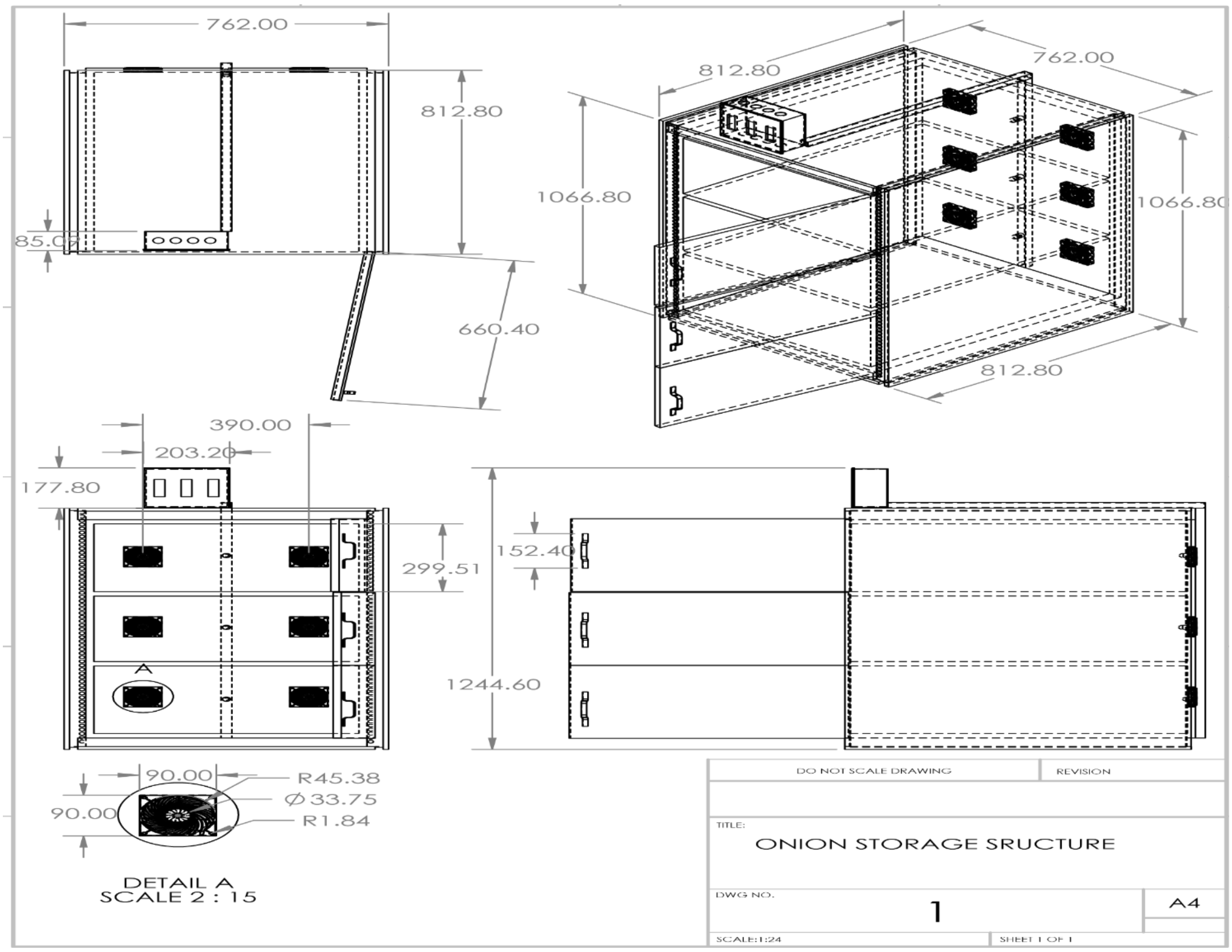
2.2 Description of the storage structure

The structure was designed to store onions in a controlled environment to optimize their quality and shelf life, it consist of three storage compartments. The compartment were independently controlled to maintain the desired storage conditions; the compartments were equipped with sensors to measure various storage conditions, such as temperature and relative humidity. These sensors were connected to a microcontroller, which controls and monitors the storage conditions and processes. The microcontroller was programmed to maintain the desired storage conditions and adjust them as needed based on the sensor readings. The compartments were also equipped with actuators, which is heating and cooling elements, to control the storage conditions. For example, the microcontroller would activate the heating element to maintain a specific temperature in the Microclimate structure compartment or turn on the fan to regulate the humidity. It also has a display or interface to allow the user to monitor and control the storage conditions and processes. Overall, the structure provides a controlled and standardized platform for storing onions in a way that maximizes their quality and shelf life. It was used to test and optimize different storage conditions and practices and would have wide applications in the food industry or for home storage as shown in Figure 1a.

Figure 1: Isometric view of the storage structure

2.3 Performance Evaluation of the structure

For the evaluation of the onion storage structures, a systematic sampling approach was employed. The study involved three compartments, each loaded with 10kg of onions. The sampling process ensured representative assessments of onion quality and storage conditions. Dadin-Kowa red onion was selected as sample of this research. This variety of onion is cultivated with normal cultural practices and have an average shelf life of 40-45 days when stored under ambient temperature. A vernier calliper was used to measure the width of the samples. The diameter of the onion bulbs ranged from 3.1 to 6.31 cm (small), 7.01 to 7.09 cm (medium) and 7.45 to 9.27 cm (large).Within each selected compartment 10kg of onions were evenly distributed to cover the entire storage area. This distribution aimed to simulate real-world storage conditions and account for potential variations in temperature, humidity, and airflow within the compartment. For optimum storage quality, onions was cured soon after harvest by placing them in a curing mode at 25-35°C and 70% relative humidity for 24 h. Curing was done to decreases the incidence of neck rot, reduces water loss during storage, prevents microbial infection, and desirable for development of good scale colour The weights



of the onions were measured at seven days interval using an analog weighing balance. Weight loss of onion was measured and expressed as percent weight loss by taking the initial and final bulb weight after respective storage interval as shown in Equation 1.

$$PLW\ (\%) = \frac{(pi-pn)}{pn} \quad \ldots 1)$$

Where;
PLW= Physiological Loss in Weight in %
Pi = Initial Weight
Pn =Weight, days after storage in %

2.4 Statistical Analysis

Microsoft excel software was used to show graphically the relationship between two quantities; an independent variable plotted on the X - axis and a dependent on Y - axis. Temperature, relative humidity and time will be independent variable while loss in weight as the dependent variable. The result was analysed using Analysis of Variance (ANOVA) to compare the difference. The Turkey's method was employed to ascertain significant difference ($\alpha \leq 0.05$) between the samples mean using Statistical Analysis Software (SAS).

3.0 Results and discussion

3.1 Anova on effects of Temperature, Relative humidity and Time on weight loss of onions

An Analysis of Variance (ANOVA) was conducted to check whether the interactions of temperature, relative humidity and time have any significant effects on weight loss of onions during storage. The results revealed that temperature had highly significant effects *(F=48035.381 and P=0.000 (P-Value) <0.05* on weight loss of onions over a period of time. Relative humidity is also highly significant *(α=.05)* in affecting weight loss.. In summary, the ANOVA analysis reveals that temperature, relative humidity, and time independently and interactively significantly influence weight loss in the microclimate storage structure. Individually, temperature, humidity, and time all play crucial roles in determining the amount of weight lost by onions during storage. Furthermore, their combined effects, particularly the interactions between temperature and relative humidity, temperature and time, and relative humidity and time, showed the complex nature of onion storage. These findings provide valuable insights for optimizing storage conditions and minimizing weight loss in onion storage facilities

Effect of temperature on weight loss

Table 1 presents the ANOVA average comparison using Turkey's mean separation method for the effect of temperature on weight loss of Onions. The comparison means explaining that means with same letters are not significantly different. The average weight loss of 21.86, 26.94 and 46.74 temperature 25, 30 and 35°c respectively were significantly different. The differences in the average weight loss clearly indicated that there was significant difference among the temperature, therefore the lowest mean of 21.86% was obtained by Temperature (T_{1}) while the highest mean of 46.74% was obtained by T_3, this mean that the higher the temperature the more the weight loss. This is in agreement with Sohany *et al.*, (2016), where they observed that weight loss of onion gradually increased with the increase of storage temperature throughout the storage period. It is recommended that for onions to have less percentage of weight loss, it should be kept at a moderate temperature.

Table 1: Effect of Temperature on Weight Loss

Temperature	Weight loss
T^1	21.86[a]
T^2	26.94[b]
T^3	46.74[c]

Means followed by same letters are not significantly different within the column at p=0.05 using Tukey Test

Effect of relative humidity on weight loss

Table 2 presents the averages of weight loss and clearly shown in that relative humidity during storage of onions had significant effect on weight loss. The averages amongst the relative humidity levels were not same. That is at least one of the average values was different. Turkey's comparison mean was conducted for the effects of relative humidity on weight loss. Average means having same letters are not significantly different. From the average, it indicated relative humidity H_1 and H_2 were not significantly different with mean values as 31.49 and 31.49%.Similarly, relative humidity of H_3 was significantly different with mean value of 32.58% while storing the onions. This is in contrast with Falayi and Isa, (2014) where they observed significant difference between relative humidity within and outside their storage structure. This contrasting results may be due to the fact that their studies is based on ambient humidity, unlike this one where by the humidity is under control.

Table 2: Effects of Relative Humidity on Weight Loss

Humidity	Weight loss
H_1	31.49[a]
H_2	31.49[a]
H_3	32.58[b]

Means with sae letters are not significantly different at p=0.05 using Tukey Test

Effect of time on weight loss

Table 3 shows the effect of time in days on weight loss of onions, the average weight loss percentage of onions keep increasing progressively over a period of time in the early stage of storage, the lowest percentage loss of 7.08 was observed after seven days of storage, the trend appears to be in progressive increase where the highest mean of 51.88 was recorded after 56 days of storage. It is evident that there is significant difference amongst the means having different letters. This implied that the longer the storage period the higher the percentage of weight loss. This is in agreement with Muktar and Nuhu, (2019) where significant difference was observed on weight loss over a certain period of storage period. It is safe to say that the longer the onions were kept under storage, the higher the percentage of weight loss.

Table 3: Effect of Time on Weight Loss

Time	Weight Loss
D_1	7.08[a]
D_2	14.28[b]
D_3	22.01[c]
D_4	29.64[d]
D_5	37.42[e]
D_6	44.47[f]
D_7	47.99[g]
D_8	51.88[h]

Means followed by same letters are not significantly different at p=0.05 using Tukey Test

Effect of temperature and relative humidity on Weight Loss

Table 4 shows the combined effects of temperature and relative humidity on weight loss of onions, the investigation into the combined influence of temperature 25,30 and 35^{O}C and relative humidity 60,65 and 70% on weight loss is obvious through the mean weight loss percentages across various temperature and humidity conditions, the lowest mean of 20.98[a] was obtained at temperature 25^{O}c (T_1) and relative humidity 65% (T_1H_2),this showed that onions stored at low temperature and moderate relative humidity is good for long term storage, on the other hand the highest mean of 47.62% was observed at higher temperature 35^{O}C and higher relative humidity 70% T_3H_3.This indicate that temperature and relative humidity had significant effects on weight loss of onions. This is in agreement with Salisu *et al, (*2019), where they found that onions stored at higher temperature and relative humidity results in low percentage of marketable bulbs. It therefore recommended that onions stored at 25°C and 65% (T_1H_2) relative humidity would have less percentage of weight loss.

Table 4: Effect of Temperature and Relative Humidity on Weight Loss

	Humidity		
Temperature	H_1	H_2	H_3
T_1	21.93^{b}	20.98^{a}	22.66^{c}
T_2	26.46^{d}	26.89^{d}	27.46^{e}
T_3	46.08^{f}	46.52^{f}	47.62^{f}

Means followed by same letters are not significantly different at p=0.05 using Tukey Test

Effect of time and temperature on weight loss

Significant difference was observed in the mean data presented in Table 5, where the effects of temperature and storage days was studied, while there is no significant difference between Temperature o25^{O}C (T_1) and 30^{O}C (T_2) after seven days of storage, this is not the same for other cases as can be seen, the highest mean of 71.52 was recorded at a very high temperature of 35^{O}C after 56 days of storage, it shows a progressive increase in the percentage of weight ,as the storage days increases so is the percentage losses, overall the results shows that onions stored at a very high temperature tend to have higher percentage weight loss compared to those stored at moderate and low temperature, this is similar to what Islam, *et.al*.,(2019) reported of higher storage losses after long term of storage.

Table 5: Effect of Time and Temperature on Weight Loss

Time	Temperature		
	T_1	T_2	T_3
D_1	5.03^{a}	5.03^{a}	11.18^{c}
D_2	10.55^{c}	9.02^{b}	23.28^{f}
D_3	16.17^{d}	15.60^{d}	34.25^{i}
D_4	19.48^{e}	23.30^{f}	46.13^{m}
D_5	23.82^{f}	32.70^{h}	55.75^{n}
D_6	28.98^{g}	40.37^{k}	64.05^{o}
D_7	32.77^{h}	43.42l	67.78^{p}
D_8	38.07^{j}	46.05^{m}	71.52^{q}

Means followed by same letters are not significantly different at p=0.05 using Tukey Test

Effect of relative humidity and time on weight loss

Table 7 shows the effects of relative humidity and time in days on weight loss of onions, at *p>0.05*, there is no significant difference among the means after seven days of storage, this is evident in the results where H_I,H_2 and H_3 all have the same mean after seven days of storage, while there exist significant differences as the time progresses, this is observed as the highest mean of 52.10^m and 52.57^m was recorded after 56 days of storage, this aligns with the findings of Berg and Lentz,(1973), Falayi and Isa (2014), and Amusat *et al.*,2022 where they reported that relative humidity and time has effects on the storage of onions. The variation in weight loss percentages across different humidity levels is particularly evident as time progresses. This indicates an interaction effect, emphasizing the importance of considering both humidity and time in understanding weight loss dynamics.

Table 7: Effect of Humidity and Time on Weight Loss

Time	Humidity		
	H_1	H_2	H_3
D_1	7.23^a	6.77^a	7.25^a
D_2	14.50^{bc}	13.60^b	14.75^c
D_3	21.40^d	$22.13d^e$	22.48^e
D_4	28.85^f	29.17^f	30.90^g
D_5	36.58^g	37.55^h	38.13^h
D_6	43.52^i	44.05^i	45.83^j
D_7	47.73^k	47.48^k	48.75^l
D_8	52.10^m	50.97^l	52.57^m

Means followed by same letters are not significantly different at p=0.05 using Tukey Test

Effects of temperature, relative humidity and time on weight loss of onions

Table 8 shows the combined effects of temperature relative humidity and time at all levels on the weight loss of onions with each entry denoting the means and significance difference, the results shows no significant difference after seven days of storage at 25^{O}C (T_1) and 30^{O}C (T_2) ,however there is significant difference at T_3. Temperature 35^{O}C T_3 consistently results in higher weight loss percentages than T_1 and T_2 while H_3 generally corresponds to higher weight loss percentages across all temperatures. The combined effect of T_3 and H_3 produced the highest weight loss percentages of 72.30 after 56 days of storage, while T_1 and H_2 produced the lowest percentage of 36.75 after 56 days of storage. Time has significant effects on weight loss as it tends to increase over time, with 35^{O}C (T_3) consistently yielding higher percentages than T_1 and T_2, this is evident as the combined effect of T_3 and later time points (D_4 to D_8) leads to the highest weight loss percentages. The results shows that Weight loss tends to increase over time, showing its significant difference with 70% (H_3) consistently yielding higher .Humidity H_3 generally corresponds to higher weight loss percentages across all temperatures, particularly when paired with T_3.In summary, the results suggest that T_3, H_3, and later time points contribute to the highest weight loss percentages. The interactions between these factors significantly influence weight loss outcomes. Statistical significance is denoted by consistent letter groupings across conditions, with different letters indicating significant differences. This results correspond to the findings of Kopic and Kurde (1989),Wolelaw *et al*.,(2014), Ahsanuzzaman, *et al*.,(2017) and Islam *et al*.,(2019).

Table 8: Effects of Temperature, Relative Humidity and Time on weight loss of Onions

'e	T_1			T_2			T_3		
%))	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H
	5.50^{a}	4.05^{a}	5.55^{a}	5.10^{a}	4.95^{a}	5.05^{a}	11.10^{de}	11.30^{de}	1
	10.50^{cde}	9.05^{bc}	12.10^{f}	9.95^{cd}	9.05^{bc}	8.05^{b}	23.05^{j}	22.70^{j}	2
	15.50^{gh}	16.05^{gh}	16.95^{h}	15.95^{gh}	16.10^{gh}	14.75^{g}	32.75^{no}	34.25^{op}	3
	18.85^{i}	19.10^{i}	20.50^{i}	22.90^{j}	22.9^{0j}	24.10^{jk}	44.80^{uv}	45.50^{v}	4
	23.50^{jk}	23.00^{j}	24.95^{k}	31.75^{mn}	32.85^{no}	33.50^{no}	54.50^{x}	56.80^{y}	5
	28.55^{l}	27.90^{l}	30.50^{m}	39.50^{rs}	40.10st	41.50^{t}	62.50^{z}	64.15^{zA}	6
	33.50^{no}	31.95^{mn}	32.85^{no}	41.50^{t}	43.50^{u}	45.25^{uv}	68.20^{C}	67.00^{BC}	6
	39.55^{rs}	36.75^{qr}	37.90^{qr}	45.00^{uv}	45.65^{v}	47.50^{w}	71.75^{D}	70.50^{D}	7

Summary

The results obtained from the study found that temperature has significant effects on weight loss in onions, at higher temperature, percentage weight loss increased with increasing in storage time. Higher temperatures accelerated the rate of moisture loss from the onions, leading to greater weight loss. Similarly, longer storage times allowed for more moisture to evaporate, resulting in increased weight loss, this is in agreement with Sohany *et al.*, (2016) findings. In summary, this study highlights the importance of controlling temperature, relative humidity, and storage time to minimize weight loss in onions during storage. Proper management of these factors can help maintain the quality and freshness of onions, reducing post-harvest losses and ensuring their availability to consumers. Temperature and storage time have a direct relationship with weight loss in onions, with higher temperatures and longer storage times leading to increased weight loss. The study demonstrates that managing temperature, relative humidity, and storage time is crucial for minimizing weight loss in onions during storage. Controlling these factors effectively can help preserve the quality and freshness of onions, ultimately reducing post-harvest losses and ensuring a longer shelf life for this important agricultural commodity.

4.0 Conclusion

Based on the results of this study, the following conclusions were drawn .The storage structure design needs humidifier for better relative humidity control, as the extractor fans has some limitations . The lowest percentage of weight loss was recorded in compartment 1 at 25^{O}C and 65% relative humidity which could be as a result of lower temperature while the highest percentage of weight loss was recorded at 35^{o}C and 70% relative humidity. The large significant difference between compartment 1 at $25^{O}C$ and compartment 3 at $35^{O}c$ indicates that the control of temperature and relative humidity within the structure has been able to reduce weight loss.

References

Ahsanuzzaman, M., Sarker, M. M., Hassan, R., Muqit, A., & Doullah, M. A. (2017). Assessment of weight loss of onion in storage due to fungi. *J. Sylhet Agril. Univ*, *4*(1), 95-100.

Arung, E. T., Furuta, S., Ishikawa, H., Tanaka, H., Shimizu, K., & Kondo, R. (2011). Melanin biosynthesis inhibitory and antioxidant activities of quercetin-3'-O-beta-D-glucoside isolated from allium cepa. *Zeitschrift für Naturforschung C*, *66*, 0209. https://doi.org/10.5560/znc.2011.66c0209

Audu, E. B., Audu, H. O., Bimbo, N. L., & Gana, J. N. (2013). Climate change and its implication on Agriculture in Nigeria. *Abuja Journal of Geography*, *3*(2), 1-15.

Biswas, S. K., .sarker, P. K., .Bhuiyan, A. M., .Mazharul, M. A., & ., B. K. (2010). Effect of irrigation on onion production. *Pakistan Journal of Biological Sciences*, *6*(20), 1725-1728. https://doi.org/10.3923/pjbs.2003.1725.1728

Bukar Y. M, Abubakar L.G, Jahun B.G (2023) ONION STORAGE STRUCTURES IN NIGERIA: A REVIEW OF THE CURRENT STATUS, CONSTRAINTS AND A MODEL FOR FUTURE PROSPECTS. *Nigerian Journal of Horticultural Science ISSN 1118-2733 Vol. 27 (1) (2023) © Horticultural Society of Nigeria, 2023*

Fumen, G. A., Osude, Z. D., & Yusuf, T. A. (2017). Effect of storage structure on design on onion bulb. *Nigerian Journal of Agricultural Extension*, *18*(3), 83-94.

Islam, M. N., Wang, A., Pedersen, J. S., Sørensen, J. N., Körner, O., & Edelenbos, M. (2019). Online measurement of temperature and relative humidity as marker tools for quality changes in onion bulbs during storage. *PLOS ONE*, *14*(1), e0210577. https://doi.org/10.1371/journal.pone.0210577

Karanja, E. K., KimaniMutiri, S. N., & Njenga, F. W. (2020). "Improving Onion Storage Techniques for Sub-Saharan Africa: A Review. *Advances in Integrated Soil Fertility Management in sub-Saharan Africa: Challenges and Opportunities*. https://doi.org/10.1007/978-1-4020-5760-1_45

Lord Abbey, Danquah OA, Kanton RA, K and Nana SO. (2000) Characteristics and storage performance of eight onion cultivars. Ghana Journal of Science.; 40.

Roy,S.K.,chakrabarti A.K.,(2002) Post-Harvest Management and Processing of Onion and Garlic *Journal of food science technology*,productionand-reducing-postharvest-losses-of-onion-in-nigeria

Tripathi, P. C., & Lawande, K. E. (2019). Top and bottom ventilated onion storage structure. *Technical Bulletin No.11, NRC Onion and Garlic, Rajgurunagar*, *6*.

Wolelaw, D., Abaye, M., Demissew, A., & Ambaye, T. (2014). Storage performance of naturally ventilated structure for onion bulbs. *Agric Eng Int: CIGR Journal*, *16397*.