Journal of Research in Forestry, Wildlife & Environment Vol. 8(4) December, 2016
http://www.ajol.info/index.php/jrfwe
jfewr ©2016 - jfewr Publications
E-mail:jfewr@yahoo.com
ISBN: 2141 – 1778
Sunmonu et al., 2016

INVESTIGATION OF DISEASE INCIDENCE AND NUTRITIONAL STORABILITY OF CASSAVA ROOTS UNDER DIFFERENT STORAGE TECHNIQUES

[1]Sunmonu, M. O.*, [1]Odewole, M. M. and [2]Ibrahim A. A.

[1]Department of Food Engineering, University of Ilorin, Ilorin, Nigeria.
[2]Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria.
*Corresponding author: sholams2000@yahoo.co.uk

ABSTRACT

A study was conducted to investigate the disease incidence and the nutritional storability of cassava roots under different storage condition, Fifty pieces each of two varieties of cassava tubers TMS 30572 and TMS 4(2) 1425 were preserved using four storage methods namely ; Trench (re-burying the cassava roots in trenches and keeping them moist by watering them daily, applying a thick coating of mud, piling the tubers in heaps and a traditionally practiced method, by randomly spreading the tubers orderly . The samples were analysed for carbohydrate, calcium, phosphorus and vitamin C. The weight loss as well as number of diseased tubers were determined, the significant difference was conducted at (p≤0.05). The mean results for the two varieties (TMS 30572 and TMS 4(2) 1425) showing the trend in the nutritional compositions and weight loss were also determined. The level of infestation of disease on the cassava tubers preserved by piling in heaps and mud application for both varieties are very low compared to the trench and the control method. The weight loss for both varieties, irrespective of the storage type is even along the storage period.

Keywords: Cassava, Disease, Preserved, storability, Storage.

INTRODUCTION

Cassava is Africa's most important staple food crop after maize and Africa produces half of the world supplies. Cassava is vital to the economy of Nigeria as the country is the world's largest producer of the commodity. The crop is produced in 24 of the 36 states in the country(USAID, 2013).Cassava is grown throughout the year, making it preferable to the seasonal crops of yam, beans, or peas. It has well- established multiplication and processing techniques for food products and cattle feed.

The composition of cassava depends on the specific tissues (root or leaf) and on several factors such as geographic location, variety, age of the plant, and environmental conditions. The roots and leaves, which constitutes50% and 6% of the mature cassava plant respectively are the nutritional valuable parts of cassava (Tewe and Lutaladio, 2004). Cassava roots have calcium, iron, potassium, magnesium, copper, zinc and manganese contents. The calcium content in cassava is relatively high compared to that of other staple crops and ranges between 15 and 35mg/100g edible portion. The vitamin C content is also high and between 15 to 45mg/100g edible portion (Okigbo, 1980; Charles *et al.* 2004). The protein, fat, fiber, and minerals are found in larger quantities in the root peel than in the peeled root.

Cassava is a major source of income in Nigeria, it is less expensive to produce, it tolerates poor soil, adverse weather and pests and diseases more than other major staples (Nweke, 2004). Cassava is playing major role in the export structure of Nigerian economy. The cassava transformation describe how the new TMS varieties, have transformed cassava from a low–yielding, farmers reserve crop to a high –yielding cash crop that is

prepared and consumed as garri, a dry cereal. Several improved varieties of cassava have been recommended and released in Nigeria. The most commonly grown of these are TMS 30572, 4 (2) 1425, 92/ 0326 and NR 8082. More recently, 42 new improved genotypes have been made available to farmers in the south-south and south-east for participatory selection so that, they can identify specific best- bet varieties for each of the cassava growing communities. For now, you could choose any of the commonly grown improved varieties for planting, since they are stable across environments. Cassava roots are much more perishable than other major roots and tuber crops. This has been attributed to the fact that the root of cassava, the storage organ, has no dormancy, has no function in propagation and processes no bud primordial from which regrowth can occur (Onwueme 1978, Cooke *et al*. 1988a;Wickam, 1988). Cassava roots generally deteriorate very quickly soon after harvest and this occurs in two separate phases: Cassava is a good source of carbohydrate**.** Cassava roots have calcium, iron, potassium, magnesium, copper, zinc and manganese contents. Cassava contains adequate amount of potassium, potassium is an important component of cell and body fluids that help regulate heart rate and blood pressure. Therefore there is need to limit the infestation of pest and diseases using different storage techniques. The aim of this research work is to investigate the effect of different storage technique on the disease incidence and nutritional quality.

MATERIALS AND METHODS

Experimental Setup

The research work was carried out at the Departmental Experimental Site of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin. Nigeria. Two varieties of Cassava are to be used for the research work. The varieties are TMS 30572 and TMS 4 (2) 1425. 50 pieces each of fresh cassava roots varieties were used for the treatments in each storage structure.

The cassava roots were buried in trenches for the period of the research and the roots were watered daily to keep it in a moist condition. The trenches were made for the two varieties of cassava to be used. The other sets cassava roots were piled in heaps without having to water them daily as in the first storage. A thick coating of clay or mud was applied on the third sets of cassava root. The control experiment is carried out at no condition. The cassava roots are spread on open ground without watering or applying any coating to the cassava. The control experiment is carried out to know how much effect the three conditions have on the cassava root.

Measurement of parameters

Estimation of disease incidence

Disease incidence was calculated as the percentage of diseased tuber per total number of tubers. The tubers were observed visually for rotting and microbial infection. Percent disease incidence was identified and calculated using the formula of Mamatha and Rai (2000).

$$DI = \frac{Do}{D} \times 100\% \qquad (1)$$

Where DI, Do and D are Disease incidence, number of diseased fruit and total number of fruits respectively.

Weight

The weights of all the samples were measured before storage using a weight balance.On the second day of storage, three (3) samples were picked at random from each treatment and labeled properly. The weight of the picked samples was taken to the laboratory for weighing. After weighing, the samples were returned back to their respective treatment and storage chambers. This process was repeated at interval of two days during the duration of the experiment and the weight changes were correctly recorded in the data book.

The change in the weight of the samples both stored in the ambient, the percentage weight were estimated using the formula expressed below

$$percentage\ weightloss = \frac{Originalweight - Newweight}{OriginalWeight} x\ 100 \qquad (2)$$

Nutritional Values

Nutritional analysis of the Cassava root was carried out at the chemistry laboratory in the University of Ilorin. The nutritional parameters evaluated were Calcium, Phosphorus, Carbohydrate and Vitamin C using AOAC (2004) methods of analysis. All measurements were performed in triplicate and results were given as mean ± standard error (SE).

Sensitivity Analysis

The effect of disease incidence on the nutritional storability of cassava roots under different storage techniques were investigated using ANOVA at $P \leq 0.05$.

RESULTS AND DISCUSSION

The nutritional parameters and the weight loss of the two varieties of cassava roots TMS 30572 and TMS 4 (2) 1425 are presented in Table 1 and 2 respectively. The analysis of variance test shows the effect of the measured parameters on the nutritional qualities and weight of stored tubers. The test shows that stored tubers using the four selected techniques (Trench, Mud, Heap and Control), the two varieties of tubers and the storage period had significant effect on calcium content, carbohydrate content, phosphorus, vitamin C and weight loss at 5% level.

Also the interactions between study parameters were also significant at 5%. The results show that depending on the variety of the tubers and storage techniques used, there exist variations on calcium content of the stored tubers. Variation was also observed in the carbohydrate contents of the stored tubers, vitamin C, phosphorus and weight of tubers also seems to vary across storage techniques. These may imply that the nutritional qualities of stored tubers under these varied storage techniques are not the same with regard to the variety and /or period of storage.

The summary statistics of the data generated as summarize on Table 3 and 4 show that depending on the variety of the tubers and storage techniques used, there exist variations in calcium content of the stored tubers. Variation was also observed in the carbohydrate contents of the stored tubers. Vitamin C phosphorus and weight of tubers also seems to vary across storage techniques. These may imply that the nutritional qualities of stored tubers under these varied storage techniques are not the same with regard to the variety and /or period of storage.

Table 3 shows that these trends were also consistent for phosphorus, vitamin C and weight loss and thus similar inference applied. It can be concluded without loss of generality that freshly stored cassava tubers not later than one week contained much higher carbohydrates, phosphorus and vitamin C. This is especially true when the tubers are stored either in trench or using the conventional method.

Table 4 shows that the two varieties of cassava tubers considered for this study do not have the same calcium content irrespective of the storage techniques used. Simply put, TMS-30572 has slightly higher calcium content than TMS-4(2)1425. Similarly, the former also had higher carbohydrates content than the later irrespective of the storage time and techniques used. These findings are consistent for phosphorus, vitamin C and weight loss.

Table 1: Summary statistics of the measured variables (nutritional parameters) in mg/100g

Storage Period	Variety	Statistics	Trench				Mud			
			Cal	CaHD	Phos	Vit C	Cal	CaHD	Phos	Vit C
Week One	TMS-30572	Mean	33.33	68.42	53.45	28.70	33.35	68.50	53.29	28.65
		SD	0.06	0.08	0.05	0.10	0.05	0.02	0.01	0.09
	TMS-4(2)1425	Mean	33.27	68.40	53.35	28.68	33.24	68.48	53.28	28.62
		SD	0.06	0.00	0.05	0.10	0.02	0.03	0.02	0.09
Week Two	TMS-30572	Mean	33.36	68.37	53.34	28.67	33.25	68.45	53.26	28.60
		SD	0.05	0.03	0.04	0.10	0.03	0.05	0.02	0.08
	TMS-4(2)1425	Mean	33.38	68.49	53.36	28.65	33.22	68.39	53.23	28.55
		SD	0.10	0.05	0.05	0.10	0.03	0.01	0.02	0.09
Week Three	TMS-30572	Mean	33.33	68.39	53.39	28.64	33.19	68.35	53.20	28.49
		SD	0.03	0.12	0.08	0.10	0.01	0.01	0.00	0.08
	TMS-4(2)1425	Mean	33.42	68.34	53.37	28.58	33.18	68.31	53.17	28.44
		SD	0.03	0.12	0.13	0.10	0.00	0.01	0.02	0.09
Week Four	TMS-30572	Mean	33.37	68.43	53.35	28.54	33.15	68.29	53.14	28.38
		SD	0.06	0.11	0.13	0.05	0.01	0.02	0.02	0.07
	TMS-4(2)1425	Mean	33.44	68.52	53.42	28.53	33.09	68.17	53.08	28.31
		SD	0.08	0.02	0.07	0.05	0.01	0.03	0.03	0.08

Storage Period	Variety	Statistics	Heap				Control			
			Cal	CaHD	Phos	VitC	Cal	CaHD	Phos	Vit C
Week One	TMS-30572	Mean	33.33	68.38	53.36	28.67	33.27	68.63	53.53	28.70
		SD	0.01	0.03	0.04	0.06	0.06	0.06	0.06	0.10
	TMS-4(2)1425	Mean	33.27	68.36	53.27	28.66	33.47	68.74	53.57	28.69
		SD	0.06	0.02	0.06	0.01	0.12	0.05	0.06	0.10
Week Two	TMS-30572	Mean	33.34	68.32	53.35	28.59	33.67	68.74	53.62	28.69
		SD	0.12	0.03	0.11	0.09	0.06	0.07	0.08	0.09
	TMS-4(2)1425	Mean	33.32	68.29	53.32	28.55	33.57	68.68	53.53	28.67
		SD	0.12	0.01	0.13	0.09	0.06	0.09	0.06	0.08
Week Three	TMS-30572	Mean	33.17	68.26	53.19	28.50	33.52	68.59	53.50	28.66
		SD	0.04	0.02	0.08	0.08	0.03	0.01	0.05	0.09
	TMS-4(2)1425	Mean	33.16	68.23	53.17	28.43	33.50	68.55	53.45	28.65
		SD	0.05	0.02	0.08	0.08	0.10	0.01	0.05	0.10
Week Four	TMS-30572	Mean	33.14	68.21	53.21	28.38	33.49	68.54	53.44	28.65
		SD	0.06	0.02	0.08	0.08	0.10	0.01	0.06	0.10
	TMS-4(2)1425	Mean	33.06	68.12	53.09	28.33	33.49	68.53	53.43	28.62
		SD	0.05	0.05	0.10	0.08	0.10	0.01	0.07	0.11

Where, Cal = Calcium CaHD = Carbohydrate Phos = Phosphorus Vit C = Vitamin C

Table 2: Summary statistics of the measured variables (weight)

Storage Period	Variety	Statistics	Weight			
			Trench	Mud	Heap	Control
Initial	TMS-30572	Mean	550.00	678.67	557.67	574.67
		SD	9.00	4.04	6.51	5.03
	TMS-4(2)1425	Mean	407.67	427.00	440.67	465.00
		SD	4.04	6.56	4.04	5.57
Week One	TMS-30572	Mean	520.00	637.33	530.33	545.00
		SD	9.54	23.86	11.50	16.09
	TMS-4(2)1425	Mean	383.00	404.00	413.33	424.67
		SD	7.55	13.23	8.74	21.55
Week Two	TMS-30572	Mean	487.00	588.67	489.67	511.67
		SD	19.47	10.60	13.01	9.02
	TMS-4(2)1425	Mean	359.00	376.33	385.00	377.67
		SD	10.54	6.03	15.10	11.06
Week Three	TMS-30572	Mean	448.00	551.33	454.67	475.33
		SD	18.08	13.05	5.51	14.57
	TMS-4(2)1425	Mean	327.67	353.67	347.33	352.67
		SD	11.59	8.08	7.02	9.71
Week Four	TMS-30572	Mean	403.67	506.67	426.33	435.67
		SD	20.98	14.64	9.02	10.07
	TMS-4(2)1425	Mean	303.33	323.00	319.33	330.00
		SD	8.02	6.56	9.50	6.00

Table 3: Analysis of variance test for measured parameters

Source	Dependent Variable	Sum of Squares	Df	Mean Square	F	Sig.
Storage Period	Calcium	0.157	3	0.052	5.851	0.001*
	Carbohydrate	0.324	3	0.108	20.116	0.000*
	Phosphorus	0.224	3	0.075	14.241	0.000*
	Vitamin C	0.563	3	0.188	26.341	0.000*
	Weight Loss	229457.573	4	57364.393	89.367	0.000*
Storage Technique	Calcium	1.299	3	0.433	48.253	0.000*
	Carbohydrate	1.615	3	0.538	100.417	0.000*
	Phosphorus	1.368	3	0.456	86.909	0.000*
	Vitamin C	0.464	3	0.155	21.688	0.000*
	Weight Loss	78128.988	3	26042.996	40.572	0.000*
Variety	Calcium	0.003	1	0.003	0.302	0.584
	Carbohydrate	0.006	1	0.006	1.182	0.280
	Phosphorus	0.026	1	0.026	5.020	0.028*
	Vitamin C	0.026	1	0.026	3.695	0.058#
	Weight Loss	479738.521	1	479738.521	747.374	0.000*
Error	Calcium	0.789	88	0.009		
	Carbohydrate	0.472	88	0.005		
	Phosphorus	0.462	88	0.005		
	Vitamin C	0.627	88	0.007		
	Weight Loss	55845.197	87	641.899		
Total	Calcium	2.248	95			
	Carbohydrate	2.417	95			
	Phosphorus	2.08	95			
	Vitamin C	1.68	95			
	Weight Loss	843170.279	95			

*significant at $p \leq 0.05$, #significant at $p \leq 0.10$

The new Duncan multiple range test on Table 4 compares the mean values of calcium content across the various storage techniques keeping other parameters constant. The result shows that calcium content of cassava tubers preserved using control method was significantly higher 33.49 mg/100g than those in trench 33.37 mg/100g, heap 33.22 mg/100g and mud 33.21 mg/100g irrespective of the variety and the time used. It has been observed that the fat level in *Dioscorear otundata* is generally low the calcium content decreased from 12.2mg to 4. 91mg and 4.76 mg in barn with fan and barn without fan, respectively after six months of storage. This could have been as the result of sprout development and growth, as some of the minerals are used for this physiological activity. (Passam*et al*., 1978). Calcium content of the stored tubers in trench, however, was significantly higher than those stored in mud and heap irrespective of the variety and the storage period. Similarly, the mean carbohydrate contents of the stored tubers in control was 68.63 mg/100g which was significantly higher than the carbohydrates value of 68.42 mg/100g, 68.37 mg/100g and 68.27 mg/100g observed in trench, mud and heap respectively. Tuber and root crops are rich in carbohydrates. Generally, carbohydrate decreased slightly during the period of storage in both barns. It has been reported that the carbohydrate content of yam tuber decreases during storage due to conversion of starch to sugar and respiratory losses of sugar as carbon dioxide. (Sahore*et al*., 2007). Similar trend was observed for phosphorus and vitamin C content of the stored cassava tubers. For weight of stored tubers, however, the result shows that higher weight were loss in trench than in all other storage techniques. More weight was also loss in heap than in mud and control techniques respectively. Mud appears to have retained the weight of tubers more significantly than all other storage techniques.

Calcium content was significantly higher in the second week compare to week one, week two and week four respectively irrespective of the storage techniques and variety. Mean calcium of stored tubers decrease starting from the third week of storage. This may imply that calcium content of stored cassava tubers depletes with time. Similarly, carbohydrate content was also seen to decrease significantly from week one through week four. This may also imply that carbohydrates contents of stored cassava tubers depletes with time.

Table 4: Multiple comparison using the new duncan range Test

Storage Period	Calcium	Carbohydrate	Phosphorus	Vitamin C	Weight
Initial	-	-	-	-	512.67a
Week One	33.31a	68.49a	53.39a	28.67a	482.21b
Week Two	33.39b	68.47b	53.38b	28.62b	446.88c
Week Three	33.31a	68.38c	53.31c	28.55c	413.83d
Week Four	33.28b	68.35d	53.27d	28.47d	381.00e
Storage Type					
Trench	33.37a	68.42a	53.38a	28.62a	418.93a
Mud	33.21b	68.37b	53.21b	28.51b	484.67b
Heap	33.22c	68.27c	53.25c	28.51b	436.43c
Control	33.49d	68.63d	53.51d	28.67c	449.23d
Variety					
TMS-30572	33.33a	68.43a	53.35a	28.59a	518.62a
TMS-4(2)1425	33.32b	68.41b	53.32b	28.56b	376.02b

Means with the same alphabet are not significantly different from each other

Graphical illustrations of the nutritional qualities and weight loss of stored cassava tubers disaggregated by variety and storage time (period)

This section presents the pictorial illustrations of the relationship between the response parameters (calcium, carbohydrates, phosphorus, vitamin C and weight loss) and various factors employed namely; storage techniques (trench, mud, heap and control), variety (TMS-30572 and TMS-4(2)1425) and storage weeks (week one, week two, week three and week four). Unlike the earlier sections, all the charts presented in this section jointly investigate or look at the simultaneous effect of the tuber variety and weeks of storage in each storage technique. The advantage is that a clear picture of what happen with the nutritional qualities of stored cassava tubers of either variety in each storage technique along the week of storage was shown.

Figure 1 shows the graphical illustrations of calcium content of the two varieties of tubers stored using the various storage techniques throughout the four weeks of storage time. The result shows that irrespective of the week of storage and variety of tubers, the conventional storage techniques seems to preserve the calcium content of cassava tubers far more than other techniques investigated. The trench technique was next most influential in preserving calcium content of stored cassava tubers irrespective of variety and week of storage. It has been observed that the fat level in *Dioscorearotundata* is generally low the calcium content decreased from 12.2mg to 4. 91mg and 4.76 mg in barn with fan and barn without fan, respectively after six months of storage. This could have been as the

result of sprout development and growth, as some of the minerals are used for this physiological activity.(Passam*et al*., 1978).

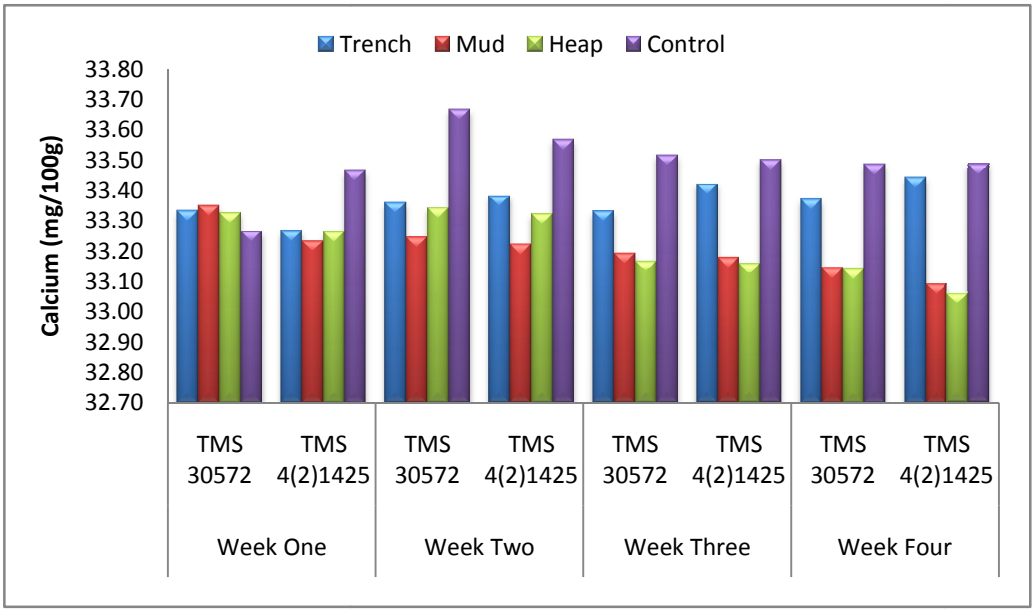

Figure 1: Graphical Illustration of the Calcium Content in the two Varieties and Storage Weeks.

Figure 2 shows the graphical illustrations of carbohydrate content of the two varieties of tubers stored using the various storage techniques throughout the four weeks of storage time. The result shows that irrespective of the week of storage and variety of tubers, the conventional storage techniques seems to preserve the carbohydrate content of cassava tubers far more than other

techniques investigated although it decrease along the storage weeks. At the fourth week of storage however, tuber stored using trench had almost the same carbohydrate content with tubers stored using the conventional method. Tubers stored in mud in the first week seem to retain higher carbohydrate content compare to trench and heap and decreases along the storage period. This is in line with (Sahore*et al*.,2007).

Figure 3 shows the graphical illustrations of phosphorus content of the two varieties of tubers stored using the various storage techniques throughout the four weeks of storage time. The result shows that throughout the four weeks of storage the TMS 30572 variety has more phosphorus content than the TMS 4(2) 1425 and the phosphorus tends to increase along the storage period. At the second week, the phosphorus content in the control experiment at the second week is at its peak for the TMS 30572. This is in line with(Sahore*et al*.,2007).

Figure 4 shows the graphical illustrations of vitamin C content of the two varieties of tubers stored using the various storage techniques throughout the four weeks of storage time. The vitamin C content is high at the first week irrespective of the storage technique or the varieties and then reduces as the storage period increases. The decrease in vitamin C content of the stored Cassava roots observed along the storage period irrespective of the storage structure is in line with Hayat *et al.,* (2003) who reported that ascorbic acid decreased significantly with incremental increase in storage duration. Ascorbic acid in fruit is sensitive to storage temperature or duration and its degradation is enhanced by adverse handling and storage conditions such as higher temperature, low humidity, physical damage and chilling injury (Adisa, 1986).

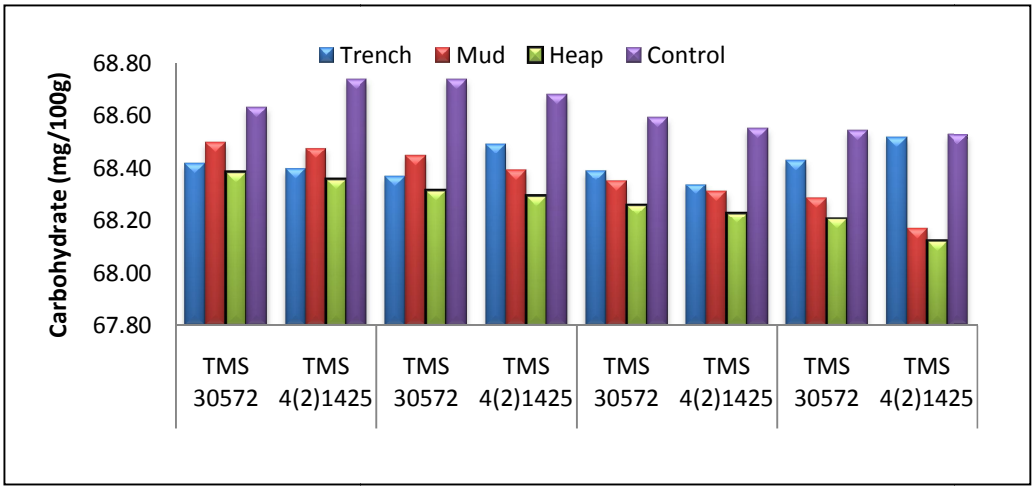

Figure 2: Graphical Illustration of the Carbohydrate Content in the two Varieties and Storage Weeks

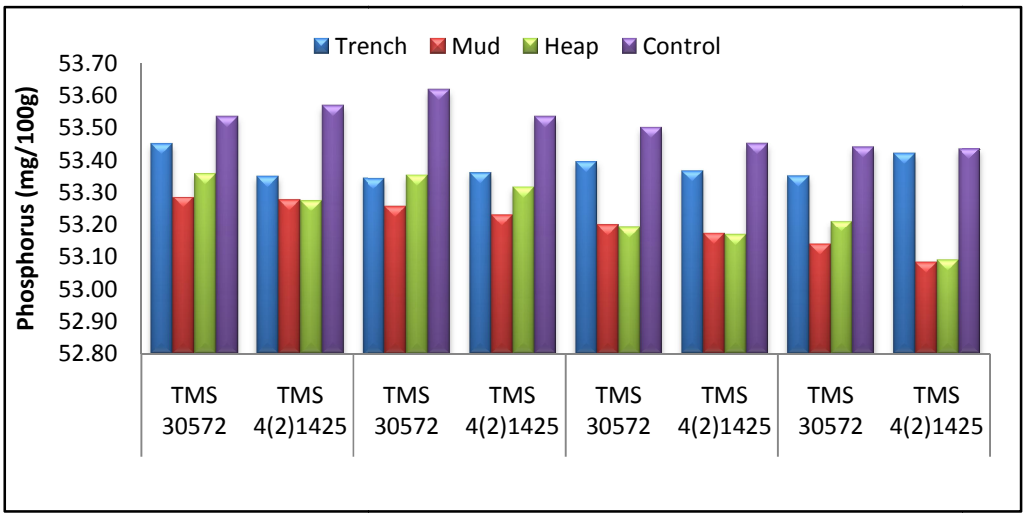

Figure3: Graphical Illustration of the Phosphorus Content in the two Varieties and Storage Weeks.

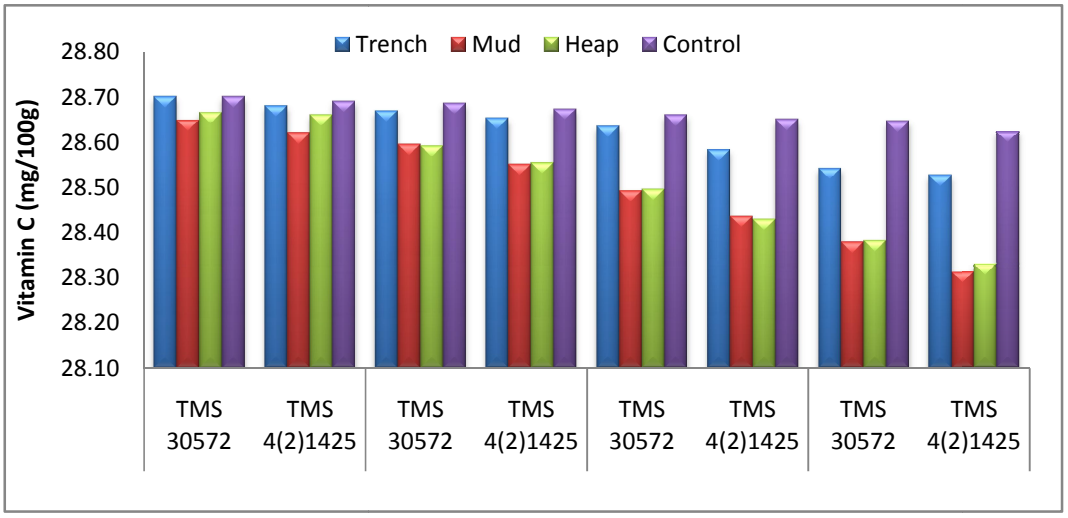

Figure 4: Graphical Illustration of the Vitamin C Content in the two Varieties and Storage Weeks.

Figure 5 shows the graphical illustrations of weight loss of the two varieties of tubers stored using the various storage techniques throughout the four weeks of storage time. The weight loss reduces evenly along storage period irrespective of the varieties. This is in line with Babarinde and Fabunmi (2009) which indicates that packaging materials had a significant ($p < 0.05$) effect on weight loss, firmness, pH and ascorbic acid.

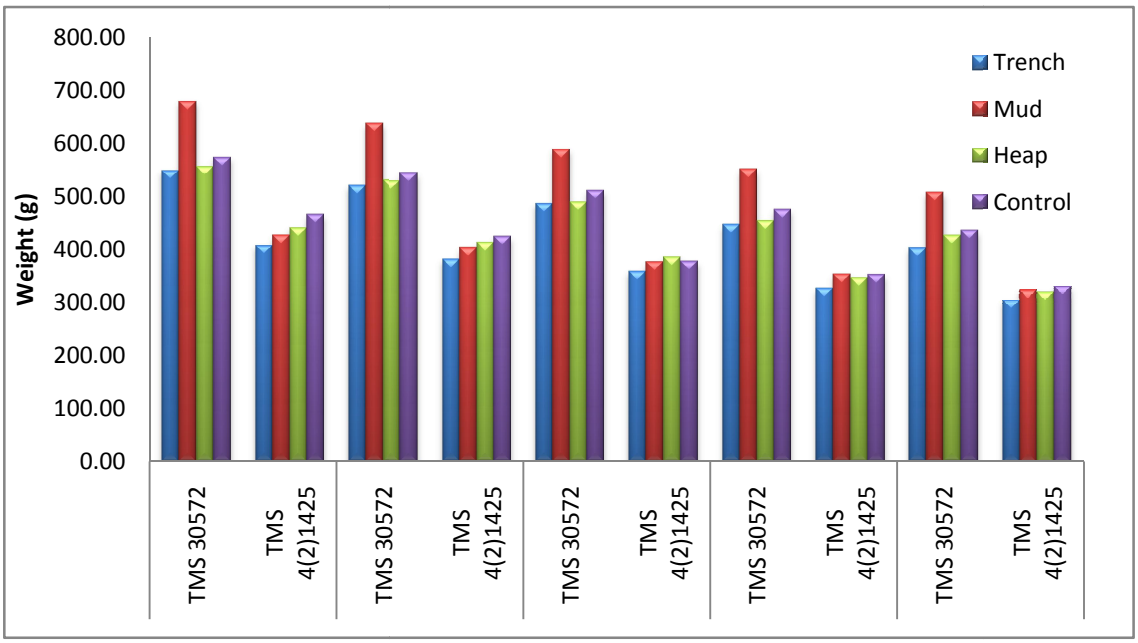

Figure 5: Graphical Illustration of the Weight Loss in the two Varieties and Storage Weeks.

Figure 6 shows the graphical illustrations of diseased tubers of the two varieties of tubers stored using the various storage techniques throughout the four weeks of storage time. At the first week of storage the number of diseased tubers for the Vb TR, Va MD, Vb MD, Va HP and Vb HP were all constant and there is a higher rate of diseased tubers in Va TR, Va CTR and Vb CTR. In the second week the rate of diseased tubers increases in Va TR and Va HP and it could be concluded that the Va MD , Vb MD, Vb HP were less resistible to disease attack.(Ihekeronye and Ngoddy,1985). It can be observed that significant reductions in moisture, crude protein, carbohydrate phosphorus and calcium content occurred throughout the period of storage in both barns.

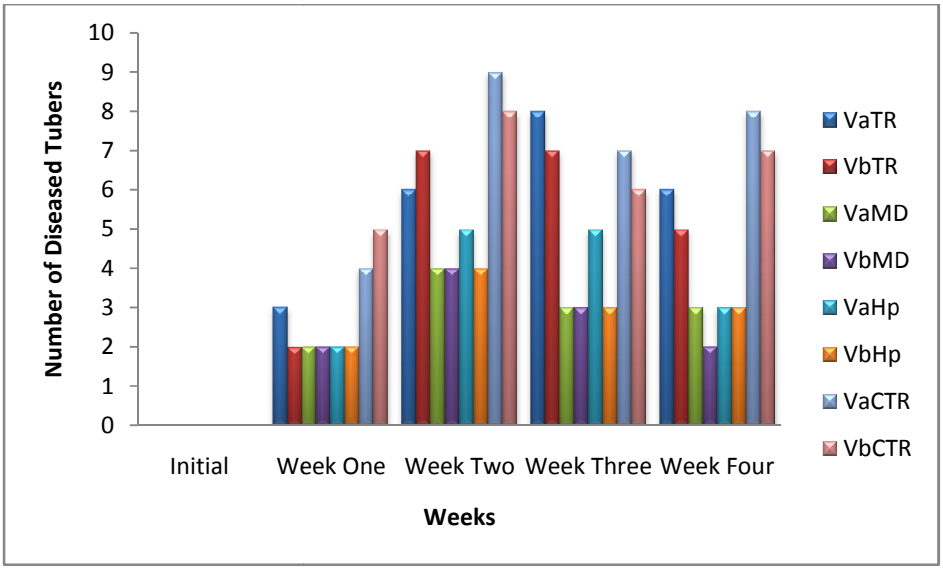

Figure 6: Graphical Illustration of the Number of Diseased Tubers in the two Varieties and Storage Weeks.

CONCLUSION

The following conclusion can be inferred from this work:

1. It can be deduced that TMS 30572 and TMS 4 (2) 1425 of the cassava roots (*Manihotesculenta*) on application of mud coating and also the storage of piling in heaps are less resistant to insect infestation at the storage period and ambient temperature of the surrounding.
2. Percentage weight loss in the cassava roots (*Manihotesculenta*) was less in both TMS 30572 and TMS 4 (2) 1425 stored by the application of mud coating than other storage technique.
3. Calcium, Phosphorus, Carbohydrate, Vitamin C of the cassava roots (*Manihotesculenta*) was better maintained/retained in cassava roots that are stored by piling in heaps for the two varieties under study TMS 30572 and TMS 4 (2) 1425.
4. It can be deduced that TMS 4(2) 1425 stored by the piling of heaps can be used as temporary store of Cassava roots (*Manihotesculenta*)

REFERENCES

Adisa, V. A. (1986): The Influence of Molds and Some Storage Factors on the Ascorbic Acid Content of Orange and Pineapple Fruits. Food Chem. 22:pp. 139–146.

AOAC (2004): Association of Official Analytical Chemist. Official Methods of Analysis 15th Edition Washington, D. C. USA 1018pp.

Babarinde, G. O. and Fabunmi, O. A. (2009): Effects of Packaging Materials and Storage Temperature on Quality of Fresh Okra (*Abelmoschusesculentus*) Fruits. AgriculturaTropicaetSubtropica 42 (4): 151-156.

Charles,A.L., Y.H. Chang, Y.H., Ko, W.C. and Sriroth T.C. (2004): Huang, Some Physical and Chemical Properties of Starch Isolates of Cassava Genotypes, *Starch/Starke***56** (2004), pp. 413–418

Cooke, R.D., Rickard J.E. & Thompson A.K., (1988a): The Storage of Tropical Root and Tuber Crops Cassava, Yam and Edible Aroids.Expl. Agric. 24:437-470

Hayat, I., Masud, T and Rathore, H.A. (2003): Effect of Coating and Wrapping Materials on the Shelf life of Apple *(Malusdomesticacv.Borkh).*InternetJournal of Food Safety. (5): 24-34.

Ihekeronye A.I. andNgoddy, P.O. (1985): Integrated Food Science and Technology for the Tropics. McMillan Publishers Ltd. London, 1985: 266 – 282 and 366 – 368.

Mamatha T.,Lokesh, S. andRai V.R.(2000): Impact of Seed Mycoflora of Forest Trees Seeds on Seed Quality and their Management. Seed Res. 28(1):59-67

Nweke F.I., Hahn, S.K and Ugwu, B.O. (1994): Circumstances of Rapid Spread of Cultivation of Improved Cassava Varieties in Nigeria. Journal of Farming System Research and Extension, 4(3): 93-119.

Nweke, Felix I., Dunstan S. C. Spencer and John K. Lynam. (2002): The Cassava Transformation: Africa's best kept secret. Lansing, Mich., USA: Michigan State University Press

Okigbo, B.N. (1980): Nutritional Implications of Projects Giving High Priority to the Production of Staples of Low Nutritive Quality. In the Case for Cassava (*Manihotesculenta*, Crantz) in the Humid Tropics of West Africa, *Food and Nutrition Bulletin***2** (1980), pp. 1–10.

Onwueme, I.C. (1978): The Tropical Tuber Crops: yams, Cassava, Sweet potato and Cocoyams. Chichester, U.K. Wiley. 234 pp.Passam HC, Read SJ and J E Rickard(1978): The Respiration of Yam Tubers and its Contribution to Storage Losses. *Trop. Agric* 1978; (**55**): 207 – 214.

Sahore DA, Nemlin G.J. and A Kamenan, A. (2007): Changes in Nutritional Properties

of Yam (*Dioscoreaspp*), green plantain (*Musa spp*) and Cassava (*Manihotesculenta*) during Storage Food Science and Technology, 2007(47), 81 – 88.

Tewe O. O. and Lutaladio N. **(**2004): Cassava for Livestock Feed in Sub-Saharan Africa. Rome, Italy : FAO

USAID, 2013 Cassava Production in Nigeria.

Wickham, L.D. (1988): The Effectiveness of Storage of Cassava Roots in Moist Media. Seventh Symposium of the International Society for Tropical Root Crops.Gosier (Guadeloupe), 1-6 July 1985. Edited by INRA, Paris.