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Effects of various storage methods on the quality and nutritional composition of sweet potato (*Ipomea batatas* L.) in Yola Nigeria

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Abstract: The effects of five different storage methods on the quality and nutritional composition of sweet potatoes was studied between December 2006 and May 2007 at Federal University of Technology Yola using randomized complete block design. The methods used for the study are modifications of existing methods that are used in Nigeria and elsewhere to suit local climatic conditions. Pits of 50X50X70 cm were dug and storage conditions varied. In each case 20 kg of freshly harvested and cured potatoes were stored. The samples were analyzed for moisture, protein, starch, and vitamins A and C before storage. Data were collected every month for five months on percent weight loss, sprouting, spoilage and other physiological changes. The samples were again analyzed for moisture, protein, starch, Vitamins A and C at the end of the five months storage period. Data collected were analyzed using the GLM procedure of SAS version 9.2 and means that were significant were separated using LSD method. Results showed significant differences among the various treatments. It was concluded that two storage methods moist sawdust in wooden box and pit storage with layer of river sand have good potentials for storage of sweet potatoes in Yola for up to five months without serious change in nutrient content and could therefore be recommended to farmers.

Keywords: sprouting, tubers, storage, sweet potatoes, curing

Introduction

Root and tubers belong to the class of foods that basically provides energy in human diet in form of carbohydrates. According to Olakesusi (2004) root and tubers refer to any grown plant that stores edible material in the roots, corms or tubers. Sweet potato (*Ipomea batatas* L.) is a root crop which is believed to have originated in Central America and was introduced to Africa probably at the end of 19th Century. It is a tropical crop with China producing 85% of the world's total while Africa accounts for just 5% (Awojobi, 2004). The plant is now widely grown as an important staple food in a number of African countries including Burundi, Rwanda, Uganda and Nigeria among others (Awojobi, 2004).

Various traditional methods of sweet potato storage such as heap storage, in-ground storage, platform and pit storage methods have been practiced in Nigeria and across African countries by farmers but the most common traditional method is the pit storage. Pit storage of sweet potatoes has been reported in Indonesia, Zimbabwe, and Malawi by Woolfe (1992) and in Nigeria by Awojobi (2004). Pit storage can generally be considered to be cheap for the rural communities since it requires minimum materials. The modifications of the various storage methods was because the methods that are being practiced do not completely prevent deteriorations and changes in the composition of the potatoes but only succeed in slowing down the rate of deterioration. Sandifolo et al. (1998) reported that the chemical composition of sweet potatoes was not much affected after 4 months storage. According to Yakubu (2005) the pit storage method appeared to be the best traditional method because deteriorations such as sprouting moisture loss and pathological losses were minimal compared to other storage methods. This agrees with earlier results of Mbeza and Kwapata (1995) who also stated that in Malawi the pit storage method is the most common traditional method of sweet potato storage and changes are minimal.

Eka (1998) reported that there is also dearth of information on nutrient changes during storage of most root and tuber crops in Nigeria. It is therefore important to carryout a systematic study of the

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effects of some storage methods on the stored sweet potatoes in order to develop improved methods of storage of the crop. This work was therefore aimed at investigating the possible changes in quality and nutritional composition of sweet potatoes during storage using different storage methods as follows:

Storage in pit (50x50x70 cm) with alternate layers of grasses and finally covered with soil. Storage in pit (50x50x70 cm) sprinkled with 30 kg of Fresh River sand then layers of sweet potato alternated with layers of sand and finally covered with a layer of soil.

Storage in modified pit (50x50x70 cm) constructed inside a hut 1.5x1.8x1.0 m and filled with alternate layers of 5 kg of fresh sand and potato (sprinkled with water) and finally 2 cm thick sand and soil.

Storage in moist sawdust packed in a wooden box (50x50x50 cm) and potatoes alternated with sawdust and kept wet by sprinkling water every week.

Heap storage on a layer of sand in a cool corner of the laboratory and covered with a layer of grasses.

Materials and Methods

Freshly harvested sweet potato tubers were obtained from Batare village within the vicinity of Federal University of Technology Yola and were carefully transported to the experimental site. The laboratory work was done in the laboratories of Departments of Biochemistry and Crop Production, Federal University of Technology Yola; located in the Northern Guinea Savannah of Nigeria between latitudes 90 14'N and longitude 120 8'E at an attitude of 158.5 m above sea level. Yola has annual means minimum temperature of 15.20C and mean maximum temperature of 390C. The relative humidity between January and March is extremely low (20-30%) and starts to increase in April until it reaches the peak (>70%) in August and September (Adebayo, 1999).

The experimental design used was randomized complete block design where the various storage methods constituted the treatments and were each replicated three times. The treatments were set up as follows:

Treatment 1: Storage in pit (50x50x70 cm) with alternate layers of grasses and finally covered with soil.

Treatment 2: Storage in pit (50x50x70 cm) sprinkled with 30 kg of fresh river sand then layers of sweet potato alternated with layers of sand and finally covered with a layer of soil.

Treatment 3: Storage in modified pit (50x50x70 cm) constructed inside a hut 1.5x1.8x1.0 m and filled with alternate layers of 5 kg of fresh sand and potato (sprinkled with water) and finally 2 cm thick sand and soil.

Treatment 4: Storage in moist sawdust packed in a wooden box (50x50x50 cm) and potatoes alternated with sawdust and kept wet by sprinkling water every week.

Treatment 5: Heap storage on a layer of sand in a cool corner of the laboratory and covered with a layer of grasses.

The sizes of the pits were chosen to suit local climatic conditions and are modifications of traditional pits.

After setting up the potato in the various storage methods it was monitored for five months and data was collected every month on:

Weight loss in sweet potato (as a % of the total weight stored), Sprouting of sweet potatoes (%), Spoilage of sweet potatoes (%), Physiological changes (%).

The freshly harvested sweet potatoes were also analyzed for their nutrient composition and the following data were collected.

Retinol (Vitamin A), Ascorbic acid (Vitamin C), Protein, Moisture, Starch (predominant carbohydrate in sweet potatoes).

At the expiration of the storage period the stored samples were carefully sorted and observations recorded. The samples form each treatment were thereafter also analyzed for moisture, protein, starch, ascorbic acid and vitamin A.

Procedure for analysis

Moisture content of the various samples was determined using hot air oven method as described by Kirk and Sawyer (1991). Protein content of the samples was determined on fresh weight basis using Kjeldhal method as reported by Kirk and Sawyer (1991). Vitamins A and C were determined by Spectrophotometric and Indophenol methods respectively (Onwuka, 2005), while starch was determined by the method of Soni et al. (1993).

All the data generated were analyzed using the generalized liner model (GLM) procedure of statistics analysis system (SAS Version 9.2 2009). Means that were significantly different were separated using the Least Significant Difference (LSD) method at P = 0.05.

Results and Discussions

Weight loss

The mean per cent weight loss of sweet potatoes stored using different storage methods for five months period are shown in Table 1. All the means were not significantly different at P = 0.05 in the 1st and 5th months but were significantly different from the 2nd to the 4th month. Potato samples stored in pit under shade with alternate layers of fresh river

Table 1. Mean percent weight loss of sweet potatoes stored for five months period with different storage methods

Treatment	1st Month	2nd Month	3rd Month	4th Month	5th Month
PTGR	11.00	46.33	-	-	-
PTRS	1.67	4.00	15.33	33.67	66.00
PSRS	5.33	6.67	.0015	30.33	-
MSWB	7.67	35.33	.0046	57.33	59.67
HRSG	15.33	54.33	-	-	-
Means	8.20	29.33	25.44	40.44	62.83
Prob. of F	0.39	0.0002	0.005	0.005	0.172
LSD	12.87	15.26	13.685	9.099	7.59

The various treatments are designated as follows:
PTGR: Storage in pit with alternate layers of grasses.
PTRS: Storage is pit with alternate layers of fresh river sand.
PSRS: Storage pit under shade with alternate layers of fresh river sand.
MSWB: Storage in moist sawdust in wooden box
HSRG: Heap storage in laboratory on fresh river sand covered with grasses.
Dash (-) : Means there were no values

Table 2. Mean percent sprouting of sweet potato stored for five month storage period.

Treatment	1st Month	2nd Month	3rd Month	4th Month	5th Month
PTGR	27.00	22.67	-	-	-
PTRS	57.67	89.67	75.66	27.00	11.00
PSRS	65.67	88.33	74.33	25.33	-
MSWB	0.00	41.67	51.33	42.67	38.00
HRSG	3.33	0.00	-	-	-
Means	30.73	48.47	67.11	31.66	24.50
Prob. of F	0.00	0.005	0.2922	0.2922	0.2461
LSD	21.916	43.728	18.009	39.901	43.95

The various treatments are designated as follows: -
PTGR: Storage in pit with alternate layers of grasses.
PTRS: Storage is pit with alternate layers of fresh river sand.
PSRS: Storage pit under shade with alternate layers of fresh river sand.
MSWB: Storage in moist sawdust in wooden box
HSRG: Heap storage in laboratory on fresh river sand covered with grasses.
Dash (-): Means there are no values

Table 3. Mean percent sweet potato spoilage for five months storage period under different storage methods.

Treatment	1st Month	2nd Month	3rd Month	4th Month	5th Month
PTGR	17.67	15.33	-	-	-
PTRS	6.33	7.33	14.33	39.33	23.00
PSRS	6.67	5.00	10.67	44.33	-
MSWB	13.00	13.67	2.67	0.00	12.33
HRSG	34.00	20.00	-	-	-
Means	15.53	12.26	9.22	27.89	17.67
Prob. of F	0.063	0.7748	0.0733	0.0733	0.1102
LSD	17.955	29.826	8.156	30.212	9.4

The various treatments are designated as follows: -
PTGR: Storage in pit with alternate layers of grasses.
PTRS: Storage is pit with alternate layers of fresh river sand.
PSRS: Storage pit under shade with alternate layers of fresh river sand.
MSWB: Storage in moist sawdust in wooden box
HSRG: Heap storage in laboratory on fresh river sand covered with grasses.
Dash (-): Means there are no values

Table 4. Mean percent physiological changes of sweet potato Stored for five months in different storage methods.

Treatment	1st month	2nd Month	3rd Month	4th Month	5th Month
PTGR	8.67	0.00	-	-	-
PTRS	0.00	89.67	70.33	27.00	11.00
PSRS	0.00	88.33	25.33	25.33	-
MSWB	30.00	0.00	51.33	42.67	28.00
HRSG	21.07	0.00	-	-	-
Means	12.07	35.60	65.33	31.67	19.50
Prob. of F	0.021	0.0001	0.2922	0.2922	0.1253
LSD	16.425	11.977	8.278	21.901	16.29
F value	0.0098	0.0001	0.0031	0.1640	0.0462

The various treatments are designated as follows: -
PTGR: Storage in pit with alternate layers of grasses.
PTRS: Storage is pit with alternate layers of fresh river sand.
PSRS: Storage pit under shade with alternate layers of fresh river sand.
MSWB: Storage in moist sawdust in wooden box
HSRG: Heap storage in laboratory on fresh river sand covered with grasses.
Dash (-): Means there are no values

Table 5. Mean percent change in various nutrients in sweet potato before and after the five month storage period

Treatments	Moisture content (%)	Protein content (%)	Starch (%)	Vit. A (mg/g)	Vit. C (mg/g)
FRBS	71.00	7.88	16.95	0.015	0.540
PTGR	-	-	-	-	-
PTRS	74.36	6.98	12.88	0.069	0.703
PSRS	86.66	7.15	10.03	0.020	0.448
MSWB	63.50	6.52	12.47	0.023	0.537
HRSG	-	-	-	-	-
Means	72.46	7.16	13.22	0.029	0.546
LSD	19.74	1.32	4.56	0.090	0.274

The various treatments are designated as follows: -
PTGR: Storage in pit with alternate layers of grasses.
PTRS: Storage is pit with alternate layers of fresh river sand.
PSRS: Storage pit under shade with alternate layers of fresh river sand.
MSWB: Storage in moist sawdust in wooden box
HSRG: Heap storage in laboratory on fresh river sand covered with grasses.
Dash (-): Means there are no values

sand had the lowest percent weight loss among the various methods up to the 4th month could not make it to the end of the 5th month. At the end of the 5th month, only those stored in moist sawdust in wooden box and pit with alternate layers of fresh river sand still had potatoes left though with high weight loss of 60 and 66% respectively. Generally, percent weight loss in stored sweet potatoes increased with storage period.

The means of percent sprouting of sweet potatoes stored for five months in different storage methods are presented in Table 2. Samples stored in pit with alternate layers of grasses and those stored in heaps in the laboratory on fresh river sand covered with grasses had low mean percent sprouting for the first two months but thereafter, they rotted away and were eliminated. Samples stored in pit with alternate layers of fresh river sand and those stored in pit under shade with alternate layers of fresh river sand attained the maximum percent sprouting at the end of the 2nd month and thereafter, had steady decreased values to the end. At the end of the 5th month storage period, samples stored in moist sawdust in wooden box had the highest mean of 38.0%.

Sweet potato spoilage

The mean percent spoilage of sweet potato for the five months storage period is shown in Table 3. The samples stored in pit with alternate layers of grasses and those stored in laboratory on fresh river sand covered with grasses and those stored in heaps in the laboratory on fresh river sand covered with grasses had the highest percent spoilage in the first two months and got rotten completely after two months of storage. Similarly, samples stored in pits under shade with alternate layers of fresh river sand lasted for only 4 months, thereafter, all the potatoes got rotten. The lowest mean percent spoilage after five months of storage was obtained from samples stored in moist sawdust in wooden box while the highest mean percent spoilage was obtained from samples stored in pits with alternate layers of fresh river sand.

Physiological changes

The mean percent physiological changes observed for five month storage period are presented in table 4. Physiological changes in the stored sweet potato were very low in the first month, and reached the peak for samples stored in pit with alternate layers of fresh river sand and those stored in pit under shade with alternate layers of fresh river sand at the end of the 2nd month and thereafter, had steady decreased values to the end. Samples stored in moist sawdust in wooden box had the peak physiological changes in the 3rd month and then decreased to the end of the storage period. The major physiological changes observed were browning and moisture loss.

Nutrient content analysis of sweet potato

The means of percent changes in the various nutrients before and after the five months storage period are shown in Table 5. Moisture content increased from the initial mean value of 71% to 74 and 87% in the samples stored in pit with alternate layer of river sand and samples stored in pit with layer of river sand under shade, respectively. Moisture content decreased in samples stored in moist sawdust in wooden box to 63.50%. Samples stored in pit with alternate layers of grasses and those stored in heaps in the laboratory and covered with dry grasses rotted away and therefore the moisture content was not determined.

The protein content of the sample before storage was 7.88 and it seems there was a general decline in the protein content as the storage period progressed. The highest mean percent protein after the five month storage was obtained in samples stored in pits with layers of river sand under shade. Samples stored in pit with alternate layers of grasses and those stored in heaps in the laboratory and covered with dry grasses rotted away and therefore the protein content was not determined.

The amount of starch decreased from the initial value of 16.95 to various values as storage period progressed. The lowest value (10.03%) was obtained in sample stored in pits with layers of river sand under shade. The vitamin A content of the stored sweet potato increased in all the samples with storage period. Sample stored in pits with alternate layers of river sand had the highest amount while samples stored in pits with alternate layers of grasses rotted away and therefore the value could not be determined. The vitamin C content increased in samples stored in pits with alternate layers of river sand after the storage period while it decreased in other samples with the lowest mean value of 0.45 mg/g in samples stored in pits with layers of river sand under shade.

Ordinarily any treatment that does to have any serious protection from environmental agents is bound to have a high weight loss because the losses due to respiration and transpiration would be high. The high weight loss recorded samples from heaps in the laboratory and covered with dry grasses in the first, second and third months might be due to high transpiration and respiration. This implied that in tropical conditions especially where the temperature is high (as in Yola), the heap storage method may not be the best option for even short term storage of sweet potato. The high weight loss observed in samples stored in pits with alternate layers of river sand in the third and fourth months was because dry grasses do not protect the sweet potatoes adequately from moisture loss. Wounding is also another factor that increases respiration rate and subsequent weight loss.

Hirose et al. (1984) reported that sweet potato having moisture content between 58-78% shared low respiration rate of 0.5 mg CO2/g dry weight per hour and the sample used for this work had a moisture content of 71%+ 0.01; but some tubers sustained wounds during transportation because of the roughness of the road. Sprouting of the sweet potatoes occurred very quickly especially when soil moisture was high and harvest delayed. It also occurs during prolong storage in condition of high temperature and humidity. The high mean percent sprouting observed in samples stored in pits with alternate layers of river sand and those stored in pits with layers of river sand under shade in the first and second months of storage agreed with the report of Ray and Ravi (2005) that the high rate of sprouting was due to high soil moisture and humidity. The general low level of sprouting observed in samples stored with sawdust in wooden boxes for the 5 months storage period may be due to low moisture, humidity and probably some chemicals substances in the sawdust.

According to Ray and Ravi (2005) the predisposing factors to microbial attack were mechanical injury and insect infestation. This was true for samples stores in heaps in the laboratory on fresh river sand covered with grasses and those stored in pits with layers grasses as there was to serious attack from *Cyclas formicarius* in these two storage methods. Among all the storage method, storage in moist sawdust in wooden boxes had the best performance because decay was minimal and the samples had little infection for the 5 months period. The low level of infection observed could be attributed to low relative humidity and probably the effects of some plant extracts from the sawdust as some workers claimed that these substances have anti-microbial properties (Bukar and Magashi, 2008) and can also speed up healing process where the potato was wounded.

There are several types of physiological changes associated with sweet potato apart from sprouting which was independently observed. These changes include the development of tiny roots, shriveling and softening of tissues. It was generally observed that the type of physiological disorder depends on the treatment or storage method. For example storage in pits with alternate layers of fresh river sand storage in pits under shade with alternate layers of fresh river sand had high rooting and sprouting while storage in moist sawdust in wooden boxes recorded no rooting, fewer and shorter sprouts. Wilcox (2006) observed

that water loss has direct influences on wilting, weight loss and it also indirectly leads to desirable and undesirable physiological changes in crops.

The changes in the nutrients (Protein, Moisture, Ascorbic acid, Vitamin A) content of the sweet potatoes after the five months storage period could be linked to the storage method like storage in pits under shade with alternate layers of fresh river sand was protected from direct sunlight and therefore the transfer of moisture was biased towards gain rather than loss while on the other hand storage in moist sawdust in wooden boxes resulted in moisture loses which was also accompanied with the nutrient losses also.

The decrease in protein content from 7.88% in fresh roots to 6.98%, 7.15% and 6.52% in pit storage with alternate layer of river sand, pit storage with layer of river sand under shade and storage in moist sawdust in wooden boxes, respectively could be attributed to findings of Ray and Ravi (2005) who reported that careless post harvest handling often leads to loss in quality and quantity of protein in extreme temperature conditions as in Yola. The fresh sweet potatoes contained 16.95% starch which even though low but falls within the range reported by Li et al. (1994). There was a general decline in starch content with storage period and according to Ray and Ravi (2005) respiration and transpiration contribute to weight loss and alteration of internal and external appearance of the potatoes. Because starch is used as a respiratory substrate, the starch content decreased during storage and subsequently the dry matter also decreased.

The vitamin A content of fresh root was determined as 0.015 mg/g on fresh weight basis and it was slightly higher than 0.01 mg/g reported by Eka (1998). The influence of post harvest storage on the vitamin content of different crops is not well understood according to Wilcox (2006) but Ascorbic acid and β-carotenes are known to fluctuate considerably.

The changes in Ascorbic acid content of fresh roots might be because Vitamin C is the most sensitive of all vitamins to processing condition and can easily oxidize when exposed to favorable conditions for oxidation (Wilcox, 2006) thus making the values to vary from the initial values. According to Ray and Ravi (2005) there is a gradual decrease in ascorbic acid content of sweet potato after storage. Kader (2006) also reported that loss in ascorbic acid content of sweet potato increase with temperature and it doubles for every 100C rise in temperature.

Conclusion

Based on the conditions under which the study was conducted, it could be concluded that the two storage methods (storage in pit with alternate layers of grasses and heap storage in laboratory on fresh river sand covered with grasses) are not good for storing sweet potato in Yola. This is because the methods did not give adequate protection to the sweet potato as they were prone to attack from termites and sweet potato weevils which also predispose the potato to microbial attack. It could also be concluded that storage in pits under shade with alternate layers of fresh river sand and storage in moist sawdust in wooden box were good for storing sweet potato in Yola for a period of up to 5 months without any significant change in nutritional composition of the crop. Storage in moist sawdust in wooden box gave better result (lower and shorter sprouts, lower rotting and spoilage, no weevil and termite infestation) probably due to the effect of the chemicals in the sawdust. Based on the results of the study, the following recommendations could be made: -

Moist sawdust in wooden box has good potential and could be used to store sweet potato in Yola Adamawa state for a period of up to five months without serious change in nutrient content of the sweet potato.

The major problem in most storage methods (like pit and heap storage methods) was sprouting and therefore sprout inhibitors like Maleic hydrazide (MH) and Naphthaline Acetic Acid (NAA) could be used to improve the effectiveness of the methods.

Extension workers should teach farmers simple measures which improve post harvest life e.g. careful handling, utilization of smaller tubers first, discarding damage/sprouted/weevil or termite infested ones.

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