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Full Length Research Paper

Effectiveness of trench and moist sawdust as storage methods for maintenance of moisture contents and microorganisims of cassava roots by variety

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Recommended cassava roots' storage methods of trench and moist sawdust were investigated for their effects on moisture contents and microbial quality of cassava roots under cooling sheds. The storage methods' shed temperatures and relative humidity were respectively similar and steady at about 24°C temperature and about 80% relative humidity. Moisture contents of the freshly harvested 'Bitter' and "Sweet" cassava roots were 57.7% and 59.9% respectively. The freshly harvested roots were uninfected, but showed various bacteria and fungi growths during storage. The bacteria and fungi species isolated from samples of stored cassava roots depended on storage method and cassava variety. The highest total bacterial load (6.48 x 10^5 cfu/g) and highest total fungal load (3.0 x 10^5 cfu/g) were within allowable load limits (10^7 cfu/g) for fresh cassava. Moisture content reduction in cassava roots was higher in trench than in moist sawdust. However, moisture content reductions in cassava roots of about 4% in trench and 3% in moist sawdust were considered low in the 6 weeks storage trial. However, microbial contamination and growths on stored cassava roots called for aseptic diligence in use of the potentially beneficial storage methods.

Key words: Cassava roots, variety, storage methods, temperature, relative humidity, moisture content, microorganisms, bacteria and fungi.

INTRODUCTION

Cassava roots, *Manihot esculenta* Crantz, have been reported (FAO, 1990; Ayoade and Adeola, 2009) as the most important of root and tuber crops in the tropics. The importance of cassava roots has been attributed to its significant source of calorie, serving as food for man and livestock (FAO, 2000; Mroso 2003). In Nigeria, the main food products from cassava roots are gari, fufu and lafun. Additionally, IITA is promoting inclusion of high quality cassava flour with wheat flour for confectionery (at up to 20% inclusion for baking of bread). Cassava also serves as industrial raw material, mainly as starch (Oluwole et al., 2004; Maziya-Dixon et al., 2007) for use in textile industries, pharmaceuticals and in production of adhesives. Meanwhile, the belief of farmers is that cassava cannot be stored post harvest. That is, cassava roots should harvested for immediate utilization (consumption, processing or sale) to avoid losses to deterioration or wastage. IITA recommended that freshly harvested cassava roots (within 24 hours of harvest) should be used for production of high quality cassava flour. Physiological deterioration of cassava roots sets in 2 - 3 days (with dehydration and internal discolouration or streaking), while microbial deterioration follows in 3 - 5 days under tropical ambient temperature and relative humidity conditions (Akingbala et al., 2005; Karim et al., 2009).

Over matured cassava roots in the field become less acceptable or rejected out rightly, as they become woody and inedible (FIRRO, 2006). In any case, Bokanga (2007) reported of traditional ground storage of cassava roots to maintain freshness of the roots until needed for sale, processing or consumption. Farmers' practice of leaving cassava roots in the field until needed serves in food security as reserve crop in the tolerance to drought during famine and other unforeseen food shortage situations. That is, cassava roots are traditionally left in

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the field after maturity until needed, at the risk of roots becoming woody or rotting in flooded fields. Thus, the importance of harvesting mature cassava roots for premium value cannot be overemphasized.

Concerning the need to harvest mature cassava roots, it has been realized that a major problem in the utilization is the poor pre – processing storage. Osunde and Fadeyibi (2011) reported that storage of agricultural raw materials is an essential aspect of food processing, to ensure that food remains available for uses. They noted that root and tuber crops are still living organisms post harvest and losses that occur during storage arise mainly due to physical and physiological conditions that followed harvest. They affirmed that the main causes of loss of root and tuber crops including cassava are associated with mechanical damage, physiological condition related maturity, respiration, water loss, sprouting, diseases and pests attack. FAO (1990) reported that these major loss causative factors need to be properly understood and appropriately controlled to ensure effective storage of root and tuber crops in the socio-economic condition of production and marketing.

In addition to the deleterious effect of field storage of cassava roots, Cooke et al. (1988), Crentsil et al. (1995) and Osunde and Fadeyibi (2011) reported of the needs for careful harvesting, selection and curing of harvested cassava roots for optimization of storage of cassava. The deleterious effects and challenges from poor storability of cassava roots post harvest have resulted in proposals and efforts at development of some storage methods for cassava roots. Particularly, methods which result in reduction of moisture loss from the roots have shown good potential for pre-processing storage of harvested cassava roots (Karim et al., 2009). These workers, Karim et al. (2009) recommended the storage of fresh harvested cassava roots in trench and moist sawdust (within one week of harvest). They found trench and moist sawdust relatively more suitable for storage of cassava roots (up to 2 weeks) than in polythene and jute bags. Further, NSPRI (1995) reported suitability of trench and moist sawdust for storage of harvested cassava roots for even much longer (up to 12 weeks), based on high visual acceptability of stored cassava root in transverse section and the suitability for use in the production of traditional food products like gari, fufu and lafun.

Towards appropriate technology development, moist sawdust in baskets or in wooden boxes at small scale (or domestic level) and use of Cassava Warehouse for large scale of cassava roots has been suggested. However, there is need for more work to establish other limits and benefits of the recommended methods for promotion and encouragement of adoption of these storage methods and further the developments of the application. Meanwhile, high relative humidity of storage atmosphere that would be expected to maintain freshness (or high moisture) of cassava roots against dehydration (or shrivelling) would also suits microbial growth and activities under tropical temperature. Therefore, microbiological studies on stored cassava roots is important in the establishment of suitability limits for storage of cassava roots under warm tropical temperature. Hence, this study was conceived to investigate the effects of the recommended cassava storage methods in the circumstances of use on the retention of freshness of cassava roots by moisture content determination, microbial contamination and growths on cassava roots varieties during storage.

MATERIALS AND METHODS

Cassava roots' storage in trench and moist sawdust

Cassava roots used for this study were 15 months old bitter variety (TMS 30572) and sweet varieties (TMS 4(2)1425) lots harvested by gently lifting out the roots from Gede farm settlement in Ayede Ekiti, Nigeria. The harvesting was done when the soil was still wet and soft after a fairly heavy rain to minimize damage in the call for carefulness in the handling by Osunde and Fadeyibi (2011). Harvesting of the roots was done with part of the stem (2 – 5 cm) still attached to limit ingress of decay into the roots (NSPRI 1995). The trimmed freshly harvested cassava roots lots were carefully transported in Pick-Up Van under leave cover to Nigerian Stored Products Research Institute, Ilorin. Palm frond was obtained from a farm along Asa-Dam Road, Ilorin for use in the cassava Trench. Fresh sawn Sawdust was obtained in bags from Irewolede Saw Mill, also near Nigerian Stored Products Research Institute, Ilorin for use in cassava warehouse. The cassava roots obtained were sorted for visibly wholesome ones and respectively shared into 2 sub-lots each, for storage in Trench or Moist Sawdust (NSPRI 1995) at Nigerian Stored Products Research Institute, Ilorin.

Monitoring of temperature and relative humidity under storage sheds

Trench and moist sawdust sheds' temperature and relative humidity were monitored daily during storage of cassava roots by the trench and moist sawdust storage methods. Thermo-hygrometers, model No JB913R by Oregon Scientific attached to the storage structures were used for reading the temperature and relative humidity of the storage sheds.

Sampling of stored cassava roots and preparation for analysis

Random samples were drawn of initial and stored cassava roots (at 2 weekly intervals) for analysis. On each occasion, cassava roots analytical sample

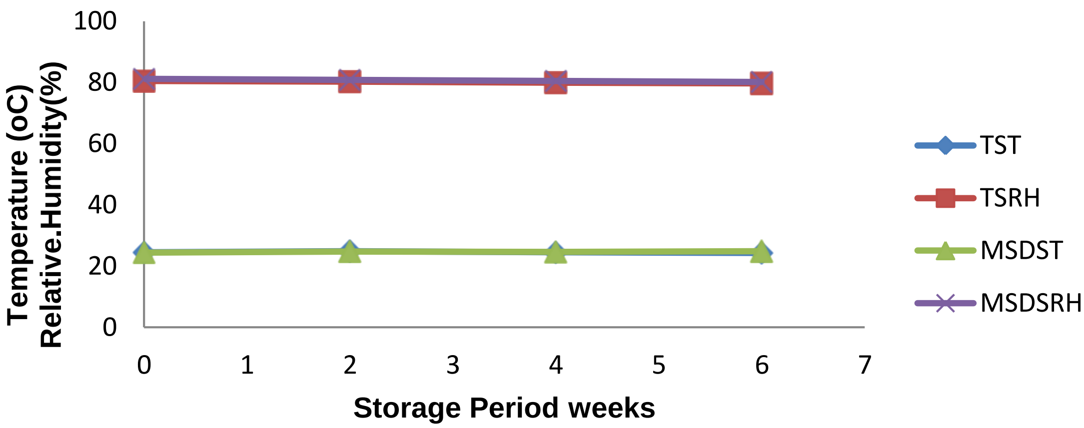

Figure 1. Temperature and relative humidity changes in trench and moist sawdust.
TST = Trench Shed Temperature, TSRH = Trench Shed Relative Humidity, MSDST = Moist Sawdust Shed Temperature, MSDSRH = Moist Sawdust Shed Relative Humidity.

consisted of portions from top, middle, and bottom levels in storage. Cassava roots' samples were rinsed with clean water to remove adhering soil or wood shavings, further rinsed with distilled water and drained. Thus, samples were ready for portioning for microbiological and moisture content analyses.

Microbiological analysis: load, isolation and characterization of pure cultures

Cassava roots were surface sterilized by swabbing surface of root with 90% ethanol solution. Sterilized stainless steel knife was used to peel cassava roots, cut them into pieces and crushed aseptically using laboratory pestle and mortal to prepare for analysis. From the mashed cassava roots 10 g was weighed into 90 ml sterile water, mixed and filtered through sterile glass wool, as suspension stock. Sterile pipette was used to draw 1 ml of stock suspension into 9 ml of sterile water in test tubes repeatedly for serial dilution (Akani and Madumere, 2008). Then, 1 ml of dilution was pour plated in sterile petri-dish using molten sterile Nutrient Agar and Potato Dextrose Agar (incorporated with 50 ppm of Tetracycline and Chloramphenicol) for bacterial and fungal cultures respectively. Plates for bacteria culture were left to gel and then incubated at 37°C for 48 h. Plates for fungal culture were also left to gel and incubated at 25°C for 72 h. Counts of colonies were made for respective dilution and load expressed in cfu/g of sample. Sub-cultures were made of the isolates for pure cultures, maintained on slants at 4°C in refrigerator to preserve as according to Fawole and Oso (2004). Tentative identification of bacterial isolates was as guided using Bergey's Manual of Determinative Bacteriology of Holt (1994). `Fungal identification was carried out according to the procedure described by Samson and Reenen-Hoekstra (1982).

Moisture content analysis

The moisture content of the samples was determined by oven drying method as according to AOAC (2005) with slight modification. Cassava roots were peeled, cut into pieces and mashed in mortar with pestle. 5 g of mashed cassava was weighed into moisture cans and placed in oven, preset to 60°C to dry for 6 h, to constant weight, rather than at 105 for 4 h. This was to avoid the burning of the wet cassava mash. Dishes were subsequently removed into desiccators to cool and then weighed. The difference in weights due to moisture loss during oven drying was used to obtain the moisture content, expressed as percentage using the formula bellow:

Moisture content, MC % = (Weight lost in drying mash cassava / Original weight) x 100.
Mean±SD for duplicate analysis were computed for moisture contents of samples.

RESULT AND DISCUSSION

Temperature and relative humidity changes in the sheds of trench and moist sawdust

Figure 1 showed temperature and relative humidity changes in sheds of trench and moist sawdust during storage of bitter and sweet cassava roots. Temperature was steady at about 24°C and relative humidity was steady at about 80%r.h. (Figure 1). That is, the temperatures and relative humidity in the sheds were similar, and fluctuations were not pronounced in the shed of the two storage methods. The storage sheds were meant to confer cool ambient condition on the stored cassava root in trench and in moist sawdust. The

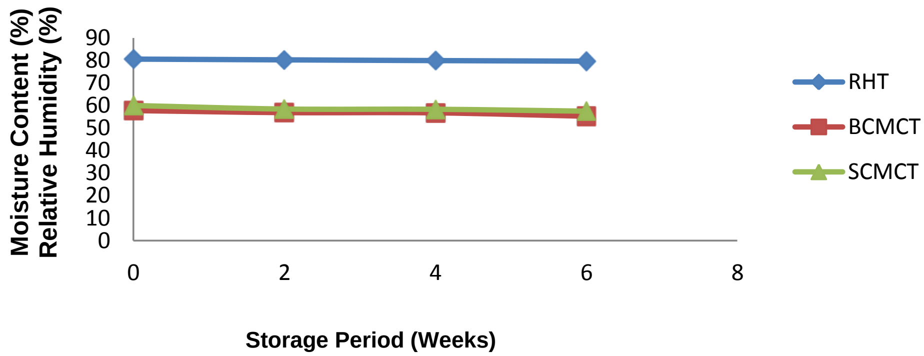

Figure 2. Moisture content and relative humidity changes of cassava varieties during storage in trench.RHT = Relative Humidity in Trench, BCMCT = Bitter Cassava Moisture Content in Trench, SCMCT = Sweet Cassava Moisture Content in Trench.

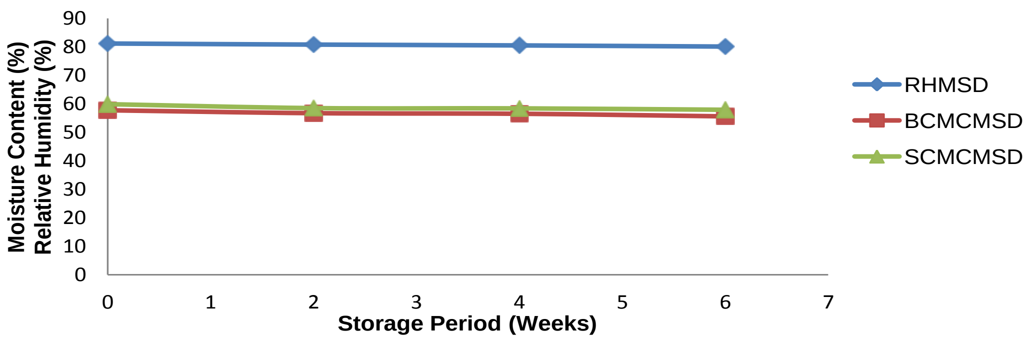

Figure 3. Moisture content and relative humidity relationship changes of cassava varieties stored in moist sawdust. RHMSD = Relative Humidity in Moist Sawdust, BCMCMSD = Bitter Cassava Moisture Content in Moist Sawdust, SCMCMSD = Sweet Cassava Moisture Content in Moist Sawdust.

relatively cool condition of the sheds (about 24°C) was much lower than in the open during the sunny afternoons, with temperature up to 32°C. The coolness of the sheds is attributable to the heat insulating material nature of roofing sheet different from the use of corrugated iron sheet, even under the open sides of the sheds.

Relative humidity / Moisture content relationship

Relative humidity changes in the Trench and Moist Sawdust sheds and changes in moisture contents associated with cassava roots during storage by the methods are shown in Figures 1 and 2. Relative humidity in the trench shed reduced from 80.50% to 79.67% during this study. The decreases in the moisture contents of stored Bitter cassava roots (from 57.70% to 55.20%) and Sweet cassava roots (from 59.90% to 57.50%) were concurrently observed with the decreased relative humidity in the Trench shed (Figure 2). Similarly, reduction in relative humidity of moist sawdust shed (from 81.20% to 80.07% r.h) was observed during this study and corresponded with decreases in moisture contents of stored Bitter cassava roots from 57.70% to 55.60% and stored Sweet cassava roots 59.90 to 57.90% (Figure 3). Result showed higher moisture contents in sweet cassava (with 59.9% moisture content at harvest) than in bitter cassava variety (57.70 % moisture content at harvest). However, although harvested cassava variety varied in moisture content, decreases in moisture contents of the stored cassava roots with decreasing relative humidity of sheds were irrespective of the cassava variety (Bitter or Sweet). Thus, the similarity in the temperature and relative humidity conditions of Trench and Moist Sawdust sheds meant similar impact on the stored cassava roots, subject only to storage methods and variety. That is, any difference can be attributed to the nature of the storage methods (Trench or Moist Sawdust) and the variety of cassava roots (Bitter or Sweet). The relative humidity / moisture content relationship was so, because stored crops' moisture tended to equilibrate with prevailing relative humidity of the environment of storage. Here because the storage methods were not under hermetic condition, they were open to the influence of the sheds' environment. Whereas, moisture content of stored cassava roots decreased as the relative humidity of

Table 1. Cultural, morphological and biochemical characteristics of bacterial isolates from 6 weeks stored cassava roots in trench and moist sawdust.

Parameters	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Cellular shape	Cocci	Rod	Rod	Rod	Rod	Rod	Rod	Rod	Cocci	Rod
Colonial elevation	Raised	Raised	Raised	Raised	Raised	Flat	Raised	Raised	Raised	Raised
Colonial edge	Entire	Lobate	Lobate	Entire	Entire	Lobate	Entire	Lobate	Entire	Entire
Colonial opacity	Opaque	Translu cent	Opaque	Opaque	Translucent	Opaque	Opaque	Translucent	Opaque	Translucent
Colonial surface	Smooth	Rough	Smooth	Smooth	Smooth	Dull	Rough	Dull	Smooth	Smooth
Colonial pigmentation	Creamy white	Cream	Creamy white	Yellow	Pink	White	Cream	Cream	NT	Yellowish cream
Cellular arrangement	Cluster	Single	Cluster	Single	Chain	Clusters	Chain	Chain	Not regular	Chain
Gram's staining	+ve	-ve	+ve	-ve	-ve	+ve	+ve	+ve	+ve	-ve
Motility test	-ve	-ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve
Spore staining	-ve	-ve	-ve	-ve	-ve	+ve	+ve	+ve		-ve
Capsule staining	-ve	-ve	-ve	-ve	+ve	+ve	-ve	+ve		-ve
Catalase test	+ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	+ve	-ve
Methyl red test	-ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve		+ve
Starch hydrolysis	+ve	-ve	-ve	-ve	+ve	-ve	+ve	+ve		-ve
Citrate utilization	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve
Oxygen reaction	FAN	AN	FAN	FAN	FAN	FAN	AN	AE	AE	AE
Lactose	AG	A	A	-ve	-ve	AG	A	-ve	+ve	-ve
Glucose	A	A	A	A	-ve	A	AG	AG	-ve	A
Sucrose	A	-ve	A	A	AG	A	A	A	A	A
Maltose	A	-ve	A	A	AG	A	AG	AG	A	A
Fructose	-ve	-ve	AG	A	AG	A	A	AG	A	AG
Probable identity	*Staphyloc occus spp*	*Acetoba cter spp.*	*Lactoba cillus spp.*	*Erwinia spp.*	*Klebsiella spp.*	*Bacillus spp.*	*Clostridi um spp.*	*Micrococus spp.*	*Bacillus spp.*	*P. aureginosa*

-ve = Negative, AE = Aerobic, AN = Anaerobic, A = Acid production, +ve = Positive, FAN = Facultative anaerobe, AG = Acid and Gas production, NT= Not tested.

sheds of storage methods decreased, the decreases in moisture of the stored cassava tubers were considered slight, at about 4% in Trench and 3% in Moist Sawdust. This also showed that relative humidity of the sheds as considerably high, and the decreases in the relative humidity during the storage trial were slight. Thus, finding in this study support the suitability of the sheds over the Trench and Moist Sawdust storage methods in fresh storage of cassava roots.

Microorganisms associated with stored cassava

Ten bacteria species; namely *Staphylococcus spp.*, *Acetobacter spp.*, *Lactobacillus spp.*, *Erwinia spp.*, *Klebsiella spp*, *Bacillus subtilis*, *Clostridium spp.*, *Micrococcus spp.*, *Bacillus cereus* and *Pseudomonas aureginosa,* and eleven fungal species, namely *Aspergillus niger val Tiaghem, Aspergilus niger, Penicillum spp., Mucor spp.* , *Neurospora spp., Candida spp., Botryodiplodia spp., Fusarium spp, Trichoderma spp., Alternaria spp.,* and *Syncephalastrum spp.* were isolated from cassava roots, but varied on cassava samples, depending on the storage method or the cassava variety. Table 1 showed characterization of the isolated bacteria in this study based on the cultural, morphology and biochemical characteristics and Table 2 described the characteristics of the isolated fungi from

Table 2. Cultural and morphological characteristics of fungi isolated from cassava during storage in Trench and Moist Sawdust, from 2nd to 6th week of storage.

Isolates	Appearance	Probable organism
F1	The colonies were compact white basal felt with a dense layer of black conidiophores with smooth walled stipe of hyaline and brown colour and radiated conidial heads split into loose columns with age..	*Aspergillus niger val Tiaghem*
F2	The colonies were well developed with hypha profusely branched, septate and hyaline. Conidia had black colour in the culture. Flat and smooth conidia were in chains at the tips of sterigmata.	*Aspergillus niger*
F3	Colony grew rapidly and was green. The phialides was flask shaped and consisted of a cylindrical basal part and distinct neck. The conidia were in long chains in columns and ellipsoidal.	*Penicillium spp.*
F4	The colony was white and wooly. The hypha were thick and non septate, columella were round. The sporagiophores departing laterally from mycelium, the sporangia were filled with spores	*Mucor spp.*
F5	The colony was broadly spread, with abundant production of ascomata; superficial or immersed, perithecial and ostiolate, dark coloured. Ascospores were ellipsoidal, unicellular, hyaline yellow brown and turned dark and opaque at maturity.	*Neurospora spp*
F6	The sporangiophores were cylindrical and the sporangial were arranged in a basipetal chain, hyaline, globose with equal thin wall, base rounded. Haustoria were globose to knob-like. Oogonia were broadly globose. Oospores were verrucose without blunt ridges with warts which were neither confluent nor branched.	*Candida spp.*
F7	Mycelium immersed, consisting of septate, branched, brown, finely verruculose hyphae. Ostiole single, circular to irregular. Conidiophores hyaline, smooth, cylindrical, rarely branched. Conidia hyaline, thick walled, aseptate, becoming dark brown, finely verrucose.	*Botryodiploida spp.*
F8	The cottony white colonies with yellowish centre grew rapidly, lighter towards the periphery. The reverse side of the colonies was off white. The hypha appeared hyaline and septate.	*Fusarium spp.*
F9	Colonies grew rapidly, hyaline at the early stage of growth and later appeared in green shades. Conidiophores were repeatedly branched bearing clusters of flask shape phialides. Conidia were hyaline with smooth wall.	*Trichoderma spp.*
F10	Colony grayish in colour. Conidiophores branched with ellipsoidal shaped conidia having cylindrical beak, not exceeding one third of the conidial length with several longitudinal septa.	*Alternaria spp.*
F11	The white colony grew rapidly covering the petridish within a week and became gray in colour with age. The main sporangiophores were with rhizoids and bore brownish terminal vesicle without septum.	*Syncephalostrum spp.*

cassava roots during this storage trial. The microbial isolates indicated the contaminating microorganisms in the environment of the stored cassava roots. That is, microbial isolates from sample were in the storage environment from where their propagules contaminated the cassava roots. However, detection of contamination, which indicated growth of the microorganisms or infection of the cassava roots was as the variety were susceptible to the attack of the organisms. That is, in the suitability of storage condition for contamination and growth of microorganisms, any constraint to microbial isolation must have been due to the peculiarity of the cassava roots' varietal characters.

The fungal isolates on cassava roots (Bitter or Sweet) stored in trench or moist sawdust were as shown in Table 3. *Aspergillus* spp. was the most commonly isolated fungi from the stored cassava roots irrespective of the variety or the storage methods in this study, while isolation of *Botryodiplodia* spp. and *Fusarium spp.* were irrespective of variety of cassava roots in trench. On the other hand, isolation of *Mucor* spp. and *Candida* spp. were irrespective of cassava variety in stored moist sawdust. Similarly, the bacteria isolates from cassava roots (Bitter or Sweet) stored in trench or moist sawdust were as shown in Table 4. *Bacillus spp., Lactobacillus spp.*, *Staphylococcus spp*. and *Pseudomonas aeruginosa* were isolated from bitter cassava roots stored in trench, while *Lactobacillus spp., Bacillus spp., Clostridium spp., Klebsiella spp*., and *Staphylococcus spp.* were isolated from Sweet cassava roots stored in trench. This showed that *Bacillus spp*., *Lactobacillus* spp and *Staphylococcus* spp. of bacteria were isolated on cassava roots stored in

Table 3. Fungi isolates on different stored cassava varieties.

Fungi	Bitter Variety		Sweet variety	
	Trench	Moist sawdust	Trench	Moist sawdust
Aspergillus spp.	+	+	+	+
Mucor spp.	-	+	-	+
Neurospora spp	-	+	-	-
Penicillum	-	-	-	+
Botryodiplodia	+	-	+	-
Fusarium spp	+	-	+	-
Trichodema spp	+	-	-	-
Alternaria spp.	-	-	+	-
Syncephalastrum spp.	-	-	+	-
Candida spp.	-	+	-	+

Table 4. Bacteria isolates on different stored cassava varieties.

Bacteria	Bitter variety		Sweet variety	
	Trench	Moist sawdust	Trench	Moist sawdust
Lactobacillus spp.	+	-	+	-
Bacillus subtilis.	+	-	+	-
Staphylococcus spp	+	+	+	+
*Pseudomonas aureg*e*nosa*	+	-	-	-
Clostridium spp.	-	-	+	-
Klebsiella spp.	-	-	+	-
Bacillus cereus	-	+	-	+
Acetobacter spp.	-	+	-	+
Erwinia spp.	-	+	-	+
Micrococcus spp.	-	+	-	+

Table 5. Microbial population of bitter and sweet cassava roots stored in trench and moist sawdust.

Trench				Moist sawdust			
Variety of cassava	Storage Period (Weeks)	Mean bacterial count	Mean fungal count	Variety of cassava	Storage Period (Weeks)	Mean bacterial count	Mean fungal count
Bitter	0	$0.0x10^3$	$0.0x10^3$	Bitter	0	$0.0x10^3$	$0.0x10^3$
	2	$2.5x10^3$	$2.0x10^3$		2	$1.5x10^3$	$1.3x10^3$
	4	$4.5x10^4$	$3.6x10^4$		4	$3.1x10^4$	$2.8x10^4$
	6	$4.25x10^5$	$2.9x10^5$		6	$3.26x10^5$	$6.7x10^4$
Sweet	0	$0.0x10^2$	$0.0x10^2$	Sweet	0	$0.0x10^2$	$0.0x10^2$
	2	$4.7x10^4$	$3.0x10^4$		2	$8.0x10^3$	$4.0x10^3$
	4	$7.2x10^4$	$5.5x10^4$		4	$3.4x10^4$	$3.5x10^4$
	6	$6.48x10^5$	$3.0x10^5$		6	$5.5x10^5$	$2.0x10^5$

trench irrespective of variety. However, *Pseudomonas aeruginosa* was specific to bitter cassava roots and *Clostridium spp.* and *Klebsiella spp*. were specific to Sweet cassava roots in trench. Further, *Bacillus spp., Acetobacter spp., Staphylococcus spp., Micrococcus spp.* and *Lactobacillus spp.* were isolated from bitter and sweet cassava roots stored in moist sawdust. That is isolation of *Bacillus* spp., *Acetobacter* spp. *Staphylococcus* spp, *Micrococcus spp*. and *Lactobacillus spp*. in moist sawdust on cassava roots was irrespective of variety.

Microbial population of bitter and sweet cassava roots stored in trench and moist sawdust were as shown in Table 5. The freshly harvested cassava roots (Bitter or Sweet) had no microbial growth either on potato dextrose agar (PDA) or nutrient agar (NA), confirming the good health and quality of fresh harvested cassava roots used for this investigation. Total counts of bacteria and fungi counts on cassava roots (Bitter or Sweet) were higher in trench that in moist sawdust stored samples. The absence of microbial isolate from freshly harvested cassava root and subsequent isolation during storage were significant as the isolations indicated growth of the microorganisms on stored cassava, commencement of spoilage activities of spoilage microorganisms. Since the microbial isolates from stored cassava were originally from the environment (air, water, soil, materials and implements), the microbial isolates were indications of poor sanitation and hygiene of storage environment in general consideration. Wide spread occurrence of *Staphylococcus spp.,* in nature is further confirmed in this study. Hence, there is the need for due sanitation and hygiene diligence for use of the storage facility to ensure safety, by prevention of hazards that may be associated with microbial contamination, growth and activities, as dictated by HACCP, SSOP and GMP concepts or principles in the use of packaging, processing, transportation, storage and marketing facilities and equipment.

While, the presence of lactic acid bacteria on the stored cassava roots has been known to contribute to flavor and odor in the use of stored cassava roots for traditional fermented products as according to Oyewole and Odunfa (1988), *Bacillus species* especially *Bacillus subtilis, was* a potential food poisoning agent (Gilbert et al., 1981) and would be of health concern if they survival normal cooking procedure. The abundance of microbial propagules in the immediate environment and proximity of cassava roots storage in Trench relative to the situation for Moist Sawdust, must have contributed to higher microbial load on cassava roots stored in Trench. However, the bacterial and fungal populations of the stored cassava in the duration of this investigation were within 1.0×10^7 cfu/g recommended limit.

Conclusion

The sheds over the recommended methods, trench or moist sawdust for storage cassava roots under ambient condition were found suitable for maintenance of freshness of cassava roots by measurement of the moisture content changes, which were considered low. This study showed that microbial load in stored cassava roots increased with the storage period, irrespective of the recommended storage methods or cassava root variety (Bitter or Sweet). In view of the observed growth and activity of the contaminating microorganisms, including spoilage and poisoning agent, it would be necessary to consider a means of controlling microbial contamination of the stored cassava roots. This will help towards optimizing the benefit of harnessing trench and moist sawdust sheds' cool and humid atmosphere for the fresh storage of cassava roots by the recommended storage methods of trench and moist sawdust under sheds for long term storage of cassava roots.

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