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Storage profitability and effectiveness of storage methods in yield loss reduction in cocoyam in southeast Nigeria

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Cocoyam is highly perishable and considerable economic losses can occur after it is harvested due to rot, sprouting and other physiological changes. This perspective hinges on the economic study of cocoyam storage in south-east Nigeria. The study was guided by null hypothesis that the mean cocoyam rot of the six storage methods did not significantly differ and that the mean income of the six storage methods did not significantly differ. Primary data was collected from 260 respondents through three sets of pre-tested questionnaires and daily/weekly monitoring of the 96 replications for the six storage methods under investigation. Secondary data came from journals, publications of the National Root Crop Research Institute, Umudike. About 85% of the respondents were 40 years and above. The net incomes of the six storage methods were ₦56.92, ₦47.96, ₦47.80, ₦43.36, ₦15.25 and ₦3.00 per kg respectively. There was statistically significant difference (P<0.01) in the mean disease severity of the six storage methods. Modern techniques of storage was not used, therefore the study recommended that government should build the capacity of storers through seminars. Additionally financial/technical support should be provided.

Key words: Cocoyam, storage methods, yield losses, Nigeria.

INTRODUCTION

Cocoyam (C*olocasia antiquorium*) originated from Southeast Asia. It was introduced into Nigeria and other West Africa countries in the 16th and 17th centuries (Bown, 2000). It is the third largest root and tubers crops in south-east Nigeria after cassava and yam in terms of production and acreage (Nwagbo et al., 1987; Ajala and Obiechina, 1987; Njoku and Obiefuna, 1987). It is a popular root and tuber crop consumed in all states in south-east Nigeria. FAOSTAT (2010) estimated the production of cocoyam in Nigeria in 2008 as 5.39 million metric tons out of a total of 11.77 million metric tons of world production.

Cocoyam is grown for its edible starchy corm and leaves, and is a major source of cheap vegetable carbohydrates, protein, fats, crude fiber, ash, carotene, thiamine, riboflavin, niacin, vitamin C and are more

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digestible when compared to other root crops (Chukwu et al., 2008). It is also a source of income for rural smallholder farmers, which produce most of the cocoyam in Nigeria. In South east Nigeria, availability and quality of cocoyam is constrained by socio-economic and technical factors and are problems for rural smallholder farmers. Food availability and accessibility can be increased by increasing production, improving distribution and reducing losses at farm, wholesale and retail level (Hodges et al., 2011). Reduction of post-harvest losses is a critical component of ensuring global food security. Food losses in low income countries mainly occur in the early and middle stages of food supply chains such as at farm, wholesale and retail level with proportionate lesser amount wasted at consumer level (Aulakh et al., 2013). Research investments have been concentrated primarily on increasing food productivity rather than reducing food losses (Kader, 2005). Increasing agricultural productivity is critical for ensuring global food security, however this may not be sufficient. Food production is currently being challenged by limited land, water and increased weather variability due to climate change. To sustainably achieve the goals of food security, food availability needs to be also increased through reductions in the post-harvest process at farm, wholesale and retail levels.

Food losses do not merely reduce food available for human consumption but also cause negative externalities to society through costs of waste management, greenhouse gas production, and loss of scarce resources used in their production. Food loss is estimated to be equivalent to 6 to 10% of human-generated greenhouse gas emissions (Gustavasson et al., 2011). A significant contributor of this problem is through methane gas generation in landfills where food waste decomposes anaerobically (Buzby and Hyman, 2012). Cocoyam is vulnerable to diseases in storage and total yield losses have been reported. Chukwu et al. (2008) reported about 50% economic losses after two months in post harvest storage and about 95% after five months as a result of rots, sprouting and other physiological changes due to poor storage techniques for cocoyam. There is a need for proper post-harvest handling and storage to reduce the incidence of loss in fresh weight, sprout and rot and to contribute to ensuring quality maintenance for perishable agricultural products. There are six mechanisms of traditional storage methods practiced by the storers (individual engaged in local cocoyam storage which could be farmers, wholesalers and retailers) in the value chain: in the basket, on the floor, and on the shelf in storage house, in raised platform, heap, and bury in the barn (Eze and Maduewesi, 1990; Ugwuoke et al., 2008).

Little research has been conducted to date to identify effective storage techniques for cocoyam that can help retain quality and marketability, and enhance income for producers, wholesalers, retailers and price economy for consumers. Thus is necessary to evaluate various cocoyam storage methods used by producers by assessing their relative effectiveness in reducing loss in fresh weight, sprouts and rots incidence as well as costs and returns of these methods.

The incentive to store cocoyam by agents is not only for planting for the next season or for food availability and to reduce negative externalities to society but also the profit to be made on sale of the stored produce. Therefore, cost of storage management, pre storage treatment as well as price fluctuation of cocoyam should all be considered. Achike (2002) noted that in practice the costs of storage system and unpredictable and variable factors like pest incidence and climatic conduction can all affect storage. The use of efficient technical method would reduce technical costs, thereby, increasing the likelihood of profit. The storage costs may be grouped as direct and indirect costs or as variable and non variable costs. Achike (2002) noted that there are three storage costs components (i) costs which are necessary to maintain and provide the physical facilities for storage (ii) costs due to quality deterioration and shrinkage during storage and (iii) the interest on capital investment in the product while in storage. Our research measured yield loss reduction across several cocoyam storage methods to show how effective each method can be in reducing post-harvest losses and other changes as well as profitability of each storage methods. Specifically, the paper sought to: describe the socio-economic and institutional factors of storers (individual engaged in local cocoyam storage such as farmers, wholesalers and retailers) and their involvement in all existing approaches to storage; assess the effectiveness of six methods of storing cocoyam (storage on floor areas, shelves and basket in the storage houses, storage by heaping the crops on the ground in the barns including on raised platforms in the barns and bury in the barns) in relation to loss in fresh weight, sprout and rot incidence; and estimate the costs and returns of the six storage techniques of cocoyam used by respondents.

MATERIALS AND METHODS

Six experiments were laid out in a 6×16 factorial in a complete randomized design (CRD) in 4 replications. The factors are methods of storage and sixteen weeks duration. One cocoyam cultivar of the *C. antiquorium* was used for the study which was conducted in south east Nigeria in 2010 and 2011.

The sampling was carried out in two phases. The first phase involved the use of stratified, multi-staged random sampling techniques to select one hundred producers, sixty wholesalers and one hundred retailers. The second phase was the purposive sampling technique to select one out of six storage sites from the two sampled states in South-east Nigeria. The storage sites were also market places and include Ibagwa, Opanda and Adazi in rural area while the urban sites are Nsukka, Enugu, and Onitsha town. The selection was based on sites that had abundance of cocoyam. Primary data collection was also carried out in two phases. The first phase involved administration by trained enumerators of three sets of structured and pre-tested questionnaires to one hundred producers, sixty wholesalers and one hundred retailers selected

through stratified, multi-staged random sampling techniques. Data were also collected from daily/weekly monitoring of six storage methods established in the store and barn. Descriptive statistics, analysis of variance (ANOVA) and net income analysis were used to analyze the data. Focus group discussion was also conducted in the six storage sites. Information was collected to identify the methods of cocoyam storage practiced by the respondents as well as socio-economic characteristics of respondents.

During the second phase, freshly harvested corms of cocoyam (C*. antiqorium)* (ede-ofe) bought from Ibagwa market (the major supply region of cocoyam (C*. antiqorium)* (ede-ofe) in Nigeria were used. Storage was carried out in the barn and storage house. The barn was heavily shaded from direct sun rays with palm fronds. Each of the six storage methods consists of four replications. Thus, there were a total of 24 replications for the six storage methods. Two hundred corms were used for each replication giving a total of 800 corms for each storage method and 4800 corms for the six storage methods. Twenty corms for each replication; 80 for each storage method and a grand total of 480 corms were randomly selected and marked for analyzing loss in fresh weight.

Calculations of the percent loss in fresh weight, rot and sprout

The mean weight of each of the six storage methods was obtained and percent loss in fresh weight were also determined and calculated using the following modified method.

Percent loss in fresh weight = [(Original weight - Final weight) / Original weight] × 100

Rot incidence = (Number of cocoyam that rot / Total number of corms) × 100

Sprout incidence = (Number of cocoyam sprout / Total number of corms) × 100

Four pits in the barn each measuring 50 × 50 × 70 cm were also dug. Ash was first spread in every side of each pit. Large quantity of dried banana leaves were spread at the bottom and sides of each pit and 200 corms of cocoyam were poured into each pits. Ash was again spread over the corms and dried banana leaves spread over the cocoyam. Then the pits were covered up with soil dug out from the pit.

For those that were heaped on the ground in the barn, banana leaves were spread on the ground and about 200 corms of cocoyam heaped on them. Banana leaves were again used to cover the cocoyam after spreading. Four replicates of this method were provided four raised platforms of the height 70 cm and 60 cm across were built in each of the six storage sites. About 200 corms of cocoyam were heaped on each of the four raised platform and covered with banana leaves.

One of the rooms in each of the six study sites was used as the storage houses. About the same numbers of corms as before (200 corms) were heaped on the floor at the corner of the room. About the same number of corm as before were heaped on the wooden shelves measuring 70 cm high and 60 cm across the centers.

Four locally made basket measuring 35 cm deep and 50 cm across were used for storing cocoyam in basket in the storage house and a total of 4 baskets for the 4 replications. Two hundred corms were poured in each of the four baskets and put in the wooden shelves in the storage house. Twenty corms were randomly taken from each of the 4 replications and marked with tapes for collecting data on loss in fresh weight.

Data for the study in the second phase was collected through the daily/weekly monitoring of the 24 replications for the six storage methods. Their losses in fresh weight were determined at weekly intervals and data was collected for 16 weeks. The mean weight of the four replicates for each of the six methods was determined and the percent loss in fresh weight determined. At each weekly sampling, any of the 200 corms showing rot or sprout was also noted. Thermometers were inserted into each of the replications and average temperature of the storage houses and barns recorded weekly. Daily relative humidity was also recorded in the barns.

The following observations were made and recorded at weekly intervals:

(a) Percent loss in fresh weight
(b) Percent cocoyam sprouting
(c) Percent cocoyam rots
(d) Daily temperature
(e) Relative humidity.

Secondary information were collected from gazettes, journals, Food and Agricultural Organization, researchers of the United Nations, World Bank publications and administrative officers of the National Root Crop Research Institute, Umudike, conference proceedings and other researchers.

Data analysis

Descriptive statistics

The respondents were described based on their age, educational background, and family size as well as of institutional factors such as sources of finance, access to extension services, methods of storage used, and membership of cooperative society and indexes using frequencies, percentages, tables and mean.

The data on rot severity were subjected to analysis of variance (ANOVA) according to the procedure described by Steal and Torrie (1980). The mean disease severity of rots incidence in the six selected storage methods were compared using Least Significant Difference (LSD) test.

Net income analysis

The net farm income technique was used to compare profit and profitability of the six selected storage methods so as to highlight the method that returned the highest investment on it. The theory of cocoyam storage is based on the fact that there is usually a time lag between production and consumption of cocoyam. The consequence of bridging the gap through the productive activity of storage using any known technology is the creation of time utility. Economists tend to maximize utility derived from a set of objectives at minimum costs while aiming at maximum output. Utility derived from storage varies with the objectives of the storers. For example while like traders aim at profit maximization, others like government agents store for price stabilization while farmers may store for food security, assurance of good propagule and even for profit. Ultimately, each category of storer aims at maximizing utility at minimum costs.

Depending on the methods used, storage is accompanied at cost in terms of resources, and the output which constitutes the stock of goods at the end of the storage periods varies. The costs of storage technology and the price of the stored product serve as the central points of storage decisions.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

Here, the socio-economic and institutional variables, as well as the storage methods used by the participants

(producers, wholesalers and retailers) were examined Socio-economic variables described are personal characteristics such as age, educational levels, gender, household size, marital status and storage methods.

Socio-economic characteristics of storage participant

Age of the respondents is an important factor in agriculture because it determines one's experience in handling cocoyam between production and consumption. The age distribution of the sample was skewed towards the upper age group of 40 and above indicating that there were relatively high proportions of middle age respondents in storage. Less than 16% of players were below 40 years. The farmers below 40 years were 11%; that of wholesalers were 5% and retailers 24%. This implies that the younger ones were less involved in storage; it also gives an indication of an aging labour force involved in adding values to cocoyam between production and consumption. This could be attributed to rural-urban migration of young ones for other nonfarm employment.

Acquisition of formal education enables one to communicate more than those who have less education or no education at all. Thus education levels also affect storage information interpretation and hence ability to maintain quality and safety during the storage process. From Table 1, 24% of respondents had no formal education starting from 10% of wholesalers to 28% of producers. On the other hand 33, 35 and 6% of the respondents attended primary, secondary and tertiary education, respectively.

With respect to gender, Table 1 shows that 37% of the interviewed participants (males) and 62% (females) involved in minimizing losses of cocoyam and its products between production and consumption. This implies that any development strategy targeted at post harvest technologies will benefit both males and females. An intense scrutiny of the statistics shows that household sizes are generally larger among the retailers where 63% have between 7 and 9 people in their family. The percentage of wholesalers with household size of between 7 and 9 people were 37% while that of farmers were 24%. Table 1 showed that most farmers had less than 7 people in their households.

The majority of the heads of households among the producers, wholesalers, retailers were married (87%) while 13% were single.

Storage methods

The results in Table 1 showed that there were no modern storage facilities such as gocing storage, ventilator or refrigerator in the study areas. About 30% of the respondents and 78% of farmers stored cocoyam between 30 and 180 days after harvesting by either storing it in the basket in the storage house or on the floor in the storage house or by heaping on the floor on the barn or on raised platform in the barn or bury it in the barn. Others, mostly wholesalers and retailers usually stored cocoyam in open storage house by heaping it on the floor or in the baskets which offered little security against theft and other risks. Storage costs can easily add up per bag in the source market as well as in the deficit market for wholesalers and retailers so they preferred to distribute as many as possible to their clients. Good storage facilities are necessary for producers, wholesalers and retailers as they maintain quality and safety, and also minimize loss of cocoyam between production and consumption.

Institutional factors of the storer

The study also describes the relevance of institutional factors such as access to extension services, need for credit and credit availability to producers or cultivators, and middlemen (wholesalers and retailers) as shown in Table 2.

Extension service

Only about 67% of producers, 3.3% of wholesalers and 15% of retailers have access to extension agents (Table 2). This results shows that in south east Nigeria, the majority of storers, especially wholesalers and retailers, have no proper linkages with the extension services. Thus, improved storage methods were lacking among farmers since extension officers are considered the most crucial source of information among farmers.

Credit need and accessibility

Credit is one of the business support services, especially for adopting improved storage methods. Business support services for all actors in cocoyam storage are pivotal so that the goal of maintaining quality and safety to minimize losses of cocoyam between production and consumption are achieved. An examination of the proportion of respondents showed that 75% needed credit to improve their storage methods. Only 22, 18 and 31% of the farmers, wholesalers and retailers respectively reported that they had no need for credit for storing their cocoyam as shown in Table 2. The table also shows the major players among formal and informal financial institutions. Microfinance institution is weak in south east Nigeria and that is why their role in lending to the respondents (7%) is smaller relative to Non Governmental Organization that lent to 26% of players, as shown in Table 2.

Table 1. Socio-economic characteristics of storage participants.

Characteristics	Producers (n = 100)	Wholesalers (n= 60)	Retailers (n = 100)	Total (n = 260)
Age of players				
21- 30 years	7(7)	0(0)	2(2)	9(3.46)
31- 40 years	4(4)	5(8.3)	22(22)	31(11.93)
41- 50 years	48(48)	47(78.4)	55(55)	150(57.69)
51- 60 years	36(36)	8(13.3)	19(19)	63(24.23)
>60 years	(5)	0(0)	2(2)	7(2.69)
Educational level				
No formal education	28(28)	10(16.7)	25(25)	63(24.23)
Primary education	24(24)	23(38.3)	46(46)	93(35.76)
Secondary education	38(38)	24(40)	24(24)	86(33.07)
Tertiary education	10(10)	3(5)	5(5)	18(6.92)
Gender				
Male	88(88)	5(8.3)	4(4)	97(37.3)
Female	12(12)	55(91.7)	96(96)	163(62.7)
Household size				
1-3	14(14)	2(3.3)	4(4)	20(7.69)
4-6	59(59)	18(30)	30(30)	107(41.16)
7-9	24(24)	37(61.7)	63(63)	124(47.69)
>9	3(3)	3(5)	3(3)	9(3.46)
Marital status				
Single	19(19)	3(5)	10(10)	32(12.31)
Married	81(81)	57(95)	90(90)	228(87.69)
Storage methods				
Basket in storage house	3(3)	0(0)	100(100)	101(39)
On the floor in storage house	5(5)	60(60)	0(0)	26(10)
Shelf in storage house	4(4)	0(0)	0(0)	92(35.38)
Storage in raised platform in the barn	8(8)	0(0)	0(0)	23(8.84)
Heaped in the barn	40(40)	0(0)	0(0)	40(15)
Bury in the barn	18(18)	0(0)	0(0)	18(6.9)

Source: Field survey (2010/2011). Figure in parentheses are percentages.

Membership of co-operatives

Most farmers belonged to a farmers' group and this enabled them access to market information as well as lowered transaction costs. Most wholesalers were also members of marketing groups and this enabled them to enjoy economies of scale. About 62% of the respondents reported that they belonged to a farmers' group as shown in Table 2. Wholesalers are also members of marketing organizations and this enabled them to pool transport, insure members and to get market information through phone.

Effects of various storage methods on the loss in fresh weight, sprout and rots incidence

Determination of percent fresh weight loss

There was progressive loss in fresh weight in each of the storage methods as the period of storage increased (Table 3). The percent loss in fresh weight was highest for the cocoyam heaped on the ground in the barn followed closely by that stored on raised platform in the same barn and lowest for those buried in the pits.

Table 3 showed the cumulative weight loss from 6 storage methods. The initial weight of the 80 corms picked from all the 4 replications weighed 3150, 2820, 2250 2560, 2440 and 2920g for storage in the pit, ground in the barn, platform, floor in the storage house, shelf, and basket respectively.

Determination of percent sprouting

The total number of cocoyam that showed incidence of sprouting or rooting differed in different methods of storage (Table 4). On the whole there was progressive

Table 2. Institutional conditions of respondents.

Socio-economic variables	Producers (n=100)	Wholesalers (n=60)	Retailers (n=100)	Total (n=260)
Extension service				
Access to extension services	67(67)	2(3.3)	15(15)	84(32.3)
No access to extension services	33(33)	58(96.7)	85(85)	176(67.7)
Need for credit				
Need for credit	78(78)	49(81.7)	69(69)	196(75.38)
No need for credit	22(22)	11(18.3)	31(31)	64(24.62)
Sources of finance				
Personal savings	61(61)	17(28.3)	80(80)	158(60.77)
NGO	28(28)	33(55)	7(7)	68(26.16)
Friends and relatives	7(7)	4(6.7)	4(4)	15(5.77)
Microfinance institution	4(4)	6(10)	9(9)	19(7.30)
Membership of co-operatives				
Member	62(62)	56(93.3)	6(6)	124(47.70)
Not a member	38(38)	94(94)	94(94)	136(52.30)

Source: Field survey (2010/2011). Figure in parentheses are percentages.

Table 3. Fresh weight loss in grams for the cocoyams in indicated storage methods and their percentages during the storage periods of four months.

Parameter	Barn			Storage house		
	Buried	Ground	Platform	Floor	Shelf	In the basket
Initial weight (g)	3150	2820	2250	2560	2440	2920
Loss in weight (g)	50	650	500	450	380	400
Percentage loss in weight (%)	1.5	23	22.2	17.5	15.6	13.7

Table 4. Total number of cocoyams under storage in each storage method and their percentage sprouting after four months of storage.

Parameter	Barn			Storage house		
	Buried	Ground	Platform	Floor	Shelf	In the basket
Total no. of cocoyams	800	800	800	800	800	800
No. of sprouted	580	350	208	188	168	200
Percentage no. of sprouted	72.5	43.5	26	23.5	21	25

rate of sprouting during the period of storage. The highest number of cocoyam that sprouted occurred in those buried and least number on those stored on the shelf and flour in the storage house as shown in the table.

During the third month of storage, insects were consistently observed to be clustering on the cocoyam in all the storage methods except the one that was stored underground. They were observed to retard the rate of sprouting and rooting when they cluster around the region. The insects were found to occur in cluster and their effect progressively increased throughout the four months.

Determination of percent rot incidence

The incidence of disease started from the first week of storage with progressive increase throughout the whole period of storage. On the whole, least incidence of rot occurred on the cocoyams stored by burying on the

Table 5. Number of cocoyams under storage in each storage method and their percentage rots incidence after four months of storage.

Parameter	Barn			Storage house		
	Buried	Ground	Platform	Floor	Shelf	Basket
Total no. of cocoyams	800	800	800	800	800	800
Total no. of rotten corms	75	320	260	210	195	192
Percentage no. of rotten cocoyams	9.4	40	32.5	26.3	24.3	24

Table 6. Effect of three storage methods in barn on corm rot severity.

Number of weeks	Storage methods in barn		
	Buried in pits	Heaped on the ground	Placed on raised platform
1	0.25	0.75	0.50
2	0.25	1.00	0.75
3	0.25	1.25	1.00
4	0.50	1.75	1.25
5	0.50	2.00	1.50
6	0.75	2.50	2.25
7	0.75	3.00	2.50
8	1.00	3.25	4.50
9	1.25	4.00	5.00
10	1.50	5.00	5.00
11	1.50	7.25	5.00
12	1.75	7.25	5.25
13	2.00	9.00	5.75
14	2.00	10.00	7.25
15	2.25	10.50	8.50
16	2.25	11.50	9.00
Mean	1.17	5.00	4.06

LSD ($p<0.05$) for comparing storage method means 1.16.

ground in the barn and on the shelf in the storage house. The greatest incidence occurred with storage by heaping the corms on the ground in the barn and on the platform in the barn. Table 5 showed the record of rots incidence for each of the storage methods during the four months of storage.

Test for hypothesis for the differences in mean disease severity

The result in Table 6 showed that there are significant differences in the corm rot severity among the storage methods in barn. Burying the corms in pits had the lowest corm rot severity which also differs significantly from what was obtained from the two other storage methods in barn. The highest rot severity was however recorded in corms heaped on the ground.

Table 7 presented the result of the effect of three storage methods in storage house on corm rot severity. The result indicated non-significant differences among the storage methods in storage house. However, corms placed in baskets had the lowest corm rot severity while corms heaped on the flour had the highest corm rot.

The mean minimum and maximum temperature throughout the period of study were 23.05 and 33.29, while the mean relative humidity was 67.01. During storage, a substantial amount of cocoyam was lost. Some of these losses are endogenous, that is, physiological such as transpiration, respiration, and germination. Other losses in cocoyam are caused by exogenous factors such as insects, pests, nematodes, rodents, rot bacteria, and fungi on store products.

Apart from traditional methods, modern methods of cocoyam storage exist in National Root Crop Research Institutes Umudike, Nigeria. The modern method includes the gocing storage. Chukuwu et al. (2008) noted that cocoyam can be stored for six months in the gocing barn. The structure of the gocing barn consists of a dwarf wall of about 1 to 1.5 m high, made up with a wire mesh to the

Table 7. Effect of three storage methods in storage house on corm rot severity.

Number of weeks	Storage methods in storage house		
	Heaped on the floor	Heaped on the shelf	Placed in baskets
1	0.25	0.25	0.25
2	0.50	0.25	0.50
3	0.75	0.75	0.75
4	1.00	0.75	1.00
5	1.50	1.00	1.25
6	2.00	1.50	1.75
7	2.50	1.75	1.75
8	3.00	2.50	2.00
9	3.25	2.25	2.50
10	3.25	3.25	3.00
11	3.75	3.75	3.50
12	4.50	4.50	4.50
13	5.00	5.00	5.00
14	6.25	5.75	5.75
15	7.00	6.75	6.00
16	8.00	8.00	8.50
Means	3.28	3.05	3.00

LSD ($p<0.05$) for comparing storage method means = 1.02.

roof. The dwarf wall and the wire mesh guarantee adequate ventilation. The wall could be of cement or brick with asbestos roofing and cemented floor. Its wall could also be made of mud with thatch or mat roofing and rammed earthen floor for the low technology type. There is no direct rain or sunlight into the store. The floor is spread (mulched) with wood shavings to a depth of 10 cm thick and watered adequately to about 50 to 70% moisture content. Consequently, a relative humidity of 60 to 80% and temperature of about 20 to 28°C is maintained in the store. The cocoyam corms and cormels are spread on the mulched floor.

Costs and returns of the six storage methods

The net income (NI) of the storage methods over the four months experimental period showed that cocoyam that was buried in pit had the highest profitability per 100 kg (one bag) compared to those stored in the storage house, such as, those stored in the basket, shelf and flour as well as those stored in the barn such as raised platform and ground.

From Table 8 the cocoyam that was heaped on the ground in the barn had the least total revenue of ₦16,500 and the least total cash expenses of ₦16,200. It also had the least net income of ₦300 per 100 kg (one bag) of cocoyam. Cocoyam that was buried had the highest net income of ₦5,962 while the net income of those that were stored in the storage house were: ₦4796, ₦4,780, ₦4,336 for shelf, basket and flour respectively. Those that were stored on raised platform had a net income of ₦1,525. This showed that storage method by burying cocoyam in pit gave the highest profit and highest return to the owner for personal and family labour, management and equity capital used in the storage operations. Expectedly, the cocoyam that was buried on the ground gave a return-on-investment of 32% compared to 29, 28 27% for the shelf, basket, floor methods in the storage house and 9 and 2% for platform and ground methods in the barn respectively. This clearly showed the superiority of the buried in the pit methods in cocoyam storage on a 100 kg (one bag) basis.

Conclusion

The findings presented here suggest that virtually no modern storage technologies such as gocing storage, ventilated storage and refrigerated storage were available for storing cocoyam by storers. One possible interpretation is that the storers do not invest if the equipment is not profitable. The storers depended on the traditional methods since these new technologies are not within their reach. The commercial producers could lose up to 70% of their output valued at $3090 during storage. Although cocoyam that was stored by burying on the ground showed the least incidence of rot, and loss in fresh weight, it had the highest costs per 100 kg bag. Looking at the return on investment those that was stored by burying has the highest return on investment. Therefore it was recommended that those who store cocoyam for up to four months should bury cocoyam on the ground. However, it is very difficult to burry large

Table 8. Net income of six cocoyam storage methods in (₦) based on 100 kg.

Item	Storage house			Barn		
	Basket	Shelf	Flour	Buried in pit	Platform	Ground
Total cash income/revenue	28,000	28,000	28,000	27,000	27,000	27,500
Value of inventory charge as a result of spoilage/loss	6,720	6,804	7,364	2,538	8,775	11,000
Total revenue (TR) in (₦)	21,280	21,196	20,636	24,462	18,225	16,500
Cash expenses (₦)						
Costs prior to storage	16,000	16,000	16,000	16,000	16,000	16,000
Labour	50	50	50	2,000	50	50
Maintenance/repairs	-	-	-	-	-	-
Treatment costs	50	50	50	400	50	50
Total cash expenses (TCE)	16,100	16,100	16,100	18,400	16,100	16,100
Depreciation	400	300	200	100	600	100
Total expenses (TE)	16,500	16,400	16,300	18,500	16,700	16,200
Net income (NI) TR-TE	4,780	4,796	4,336	5,962	1525	300
Return on Investment NI/TE	0.28	0.29	0.27	0.32	0.09	0.02

Source: Field Survey (2010/2011).

quantities of cocoyam on the ground and may not be feasible for commercial producers that could store more than 10 tons of cocoyam. There is need for research that could compare the modern and traditional technology to see if the commercial storers could realize a better return on investment by embarking on the modern storage in the research institute. This will also require access to credit and extension for financial/technical support as well as training through seminar to encourage them on the use of improved method of storage.

Conflict of Interests

The authors have not declared any conflict of interests.

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