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YAM STORABILITY AND ECONOMIC BENEFITS OF STORAGE UNDER THE MODERN (UNDERGROUND) AND TRADITIONAL (YAM BARN) TECHNOLOGIES IN SOUTHEASTERN NIGERIA

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ABSTRACT

This paper examines yam storability and the economic benefits of storage under the modern (underground) and the traditional (yam barn) storage technologies in Southeastern Nigeria. Data were collected mainly from 55 respondents who were interviewed, as well as from measurement of storage parameters on yam tubers stored in 55 traditional yam barns and 11 modern underground yam storage structures.

The results show that on the average about 55 percent of the tubers stored under the modern technology and less than 20 percent of the tubers stored under the traditional system remained in a fairly good condition after the fifth month of storage; and the value of storage loss was about N46,231 for the traditional yam barn and N23,951 for the modern storage system per 1000kg of tubers stored under both systems. Hence the value of storage losses under the traditional system was about 55 percent higher than that under the modern system.

On the average about 400kg yams valued at N22,280 was saved from 1000kg of yams stored under the modern storage technology for a period of five months. The net benefits would be significantly higher if the full potentials of the modern storage technology are exploited especially in terms of prolonged storage which attracts higher revenue from stored tubers.

Key words: *Yam; storability; modern; traditional; technology.*

INTRODUCTION

Problem Statement

There has been persistent problem of food shortage in developing countries, including Nigeria. Presently in Nigeria, the problem is not so much of low output as of inability to effectively preserve much of what has been produced over time. Storage losses occur in virtually all agricultural products, and the magnitude has been reported to range from about 20 to 80 percent of total output (National Research Council, 1977; Orraca-tetteh, 1978; Sanchez, 1976).

Yam (D.spp) are grown extensively in Nigeria, and West Africa, and also in other parts of Africa, Asia and the Caribbens. In Nigeria, especially in the Southeastern States, priority attention is given to yam production in terms of farm resources allocation relative to other crops because of its high socio-cultural significance among the people (Okorji and Obiechina, 1985). Incidentally out of the relatively high output of yam less than 20% is made available to non-producers. Although a significant proportion of the output is consumed as well as used for socio-cultural purposes, a reasonable proportion is usually lost in storage. Revenue realised from yam enterprise is also relatively low as the farmers sold most of their yams soon after harvest at relatively low prices.

Storage losses have been significantly higher in roots and tuber than in cereals. While several traditional and modern technologies exist for the storage of cereals, there exist no modern method of tuber storage at the small-holder level; and the tying of tubers on stakes and heaping on a raised platforms constitute the predominant traditional storage methods. The traditional yam barn and its variants are the main storage structures available to the farmers, and substantial losses of up to 60 percent have been recorded for tubers stored in the traditional barns (Ezeike, 1987;Coursey, 1983; Adesuyi, 1979; Orraca-tetteh, 1978).

The traditional processing of yams into chips and flour as a means of storage is practiced in some localities (Adenuga, 1979; Olorunda, 1979; plucknett, 1979; Coursey and Ferber, 1979). Storage losses of yam chips and flour are relatively low especially when adequately dried. Yam chips and flour, however, do not serve as substitutes for the yam tuber which has high socio-cultural significance among most people of Southeastern Nigeria (Okorji and Obiechina, 1985; Arua, 1981). This highlights the need for the development of effective storage technology for yam tubers.

Researches have been conducted on the use of cold storage, ionizing radiation and chemical treatments among others to improve on yam tuber storage (Adesiyan, 1977; Adesuyi, 1982; Ikediobi, 1983; Been et al, 1977). Although these have produced positive results, the technologies are often too advanced and very costly for adoption by the average farmer. What is required is a fairly simple modern technology that is affordable and readily available to yam farmers and dealers for adoption, as is the case with the proposed modern (underground) yam storage technology.

The effects of certain biological and environmental factors on storability or yam tubers have been investigated. For instance, considerable loss in weight of stored yam tubers in Nigeria due to temperature was observed (Adesuyi and Mackenzie, 1976; Orraca-tetteh, 1978). Similarly, the effects of relative humidity, insect and pest infestation of storage, tuber size and maturity at harvest etc on storage losses of yam tubers have been investigated (Adesuyi, 1979; Sanchez, 1976; Treche and Guion, 1980). The modern (underground) yam storage technology is designed to effectively address the adverse effects of temperature, relative humidity, insect and pest infestation etc on stored yam tubers.

Successful introduction of this technology for farmers will provide a much expected alternative storage structure for yam. The farmers will lose less of their harvest and therefore enjoy greater economic returns. The factors of deterioration can be brought under control. Yams can be stored in a fresh condition for long periods, thus stimulating local food industries which use yam as raw materials.

Objectives of the study

The broad objective of this study is to determine the storability and economic benefits of yam tuber storage under the modern (underground) and the traditional (yam barn) storage technologies in Southeastern Nigeria.

The specific objectives of the study are to:

a) describe the traditional yam storage methods used by farmers, and the modern (underground) yam storage technology;

b) compare the performance of the modern (underground)storage technology and the traditional system in terms of storability of yam tubers;

c) analyse the effects of biological and climatic factors on yam tuber storage under the traditional yam barn and the modern structure; and

d) determine the economic gains of the modern yam storage technology against the traditional storage system.

MATERIALS AND METHOD

The study was conducted in Anambra, Benue, Bendel/Delta, Enugu/Ebonyi and Cross River States of Southeastern Nigeria. Onwueme (1978) reported that of the 69% of the world total area of yam which Nigeria cultivates, Anambra, Benue, Bendel and Imo States of Southeastern Nigeria provide 40 percent. Bachmann and Winch (1979) also observed that a carefully selected sample of locations in the Anambra Basin and Abakaliki areas would represent the humid zone half of the yam production belt of Nigeria. These provide justification for the selection of the study locations.

In each of the five states, two communities were selected at random from the list of communities in the state. The selected communities include Nteje, Ogbaru, Asaba, Ogwashi, Abakiliki, Oraukwu, Enugu Ezike, Yandev, Manuwem, Obubra and Ikom. In addition to the 10 communities randomly selected, the University of Nigeria, Nsukka was purposively selected as the eleventh community for experimental control.

The modern yam storage structure was

constructed in each of the eleven communities selected for study. In addition, a random sample of five respondents was drawn in each of these communities from the list of yam farmers. The study was restricted to yam farmers firstly because they mostly use the traditional yam barn system under study, and secondly, they usually keep their yams in these barns for relatively long periods, often times from one season to the other. The yam barn of each of the selected farmers was hence used for study. Thus, a total of 55 respondents, eleven modern yam storage structures and 55 traditional yam barns were used for the purpose of this study.

The traditional yam storage systems used by farmers in each community were studied through the use of structured questionnaires administered to the selected farmers as well as personal observations and measurements. The new yam storage structures and the farmers yam barns were stocked with yams at the same time. Biological and environmental parameters, temperature, relative humidity and storage indices (weightloss, sprouting, decay, shrinkage, appearance etc) were monitored on biweekly basis for each year of study. Market prices per unit weight of yam were also collected in each of the study locations on biweekly basis. The study was conducted from, January- December in 1997 and 1998, and average values were taken for the two years.

The data collected were analyzed using both statistical and econometric tools. For instance, objectives (a), (b) and (d) were achieved using means, percentages and tables while objective (c) was achieved using a multiple regression model.

RESULTS AND DISCUSSION

Traditional Yam Storage Methods used by the farmers

There were three main yam storage methods used by farmers in the study areas. These include tying of yam tubers on stakes in the yam barn, heaping of yam tubers on raised platforms in the yam barn, and heaping of tubers in the living rooms. It was observed that most of the respondents used more than one of these traditional storage methods in storing their yams. For instance, 92% of the farmers stored their yams by tying them on stakes in the barn, 24% stored by heaping them on raised platforms in the barn, while 12% stored their yams in the rooms in their residential homes. On the average, it was estimated that about 84% of the yams were stored by tying on stakes in the barn, 12% were stored by heaping in the barn while only 4% of the yams were stored in rooms. Hence tying of yams on stakes in the barn was the most important traditional yam storage system in the study areas.

The traditional yam barn is usually constructed with bamboo and sticks. In the major yam producing areas a permanent site, preferably in a corner of the farmer's compound, is chosen and small live sticks are grown in lines and supported with bamboos for the purpose. Ropes are used to tie the tubers onto the sticks, with the yams arranged one on top of the other. The capacity of an average yam barn is fairly large, and between 2000-3500 tubers could be stored depending on the number of lines in the barns and output of yams. In many cases palm fronds are used to provide shades in the barns. The costs of the materials used ranged between N4500 to N8000 on the average for a barn with about four lines (2000 tubers). The life span of the traditional yam barn is about three years, and it is estimated that farmers spent between N2200 to N3800 yearly on repairs and maintenance including replacement of bamboos, ropes and stakes. The cost is however, lower where the stakes are live trees. The depreciated value of the traditional yam barn, however, amounts to about N4900 per annum for the three-year useful life.

The Modern Yam Storage System

This system entails storage of yam underground, in pits of about 2.9m x 2.8 x 1.5m. The pit has an inlet staircase, with roofs of corrugated sheets and a chimney with mesh on opposite sides to enhance cross ventilation. The roof is based on solid structure of about 0.69m constructed round the pit. The inside of the roof is covered with ceiling board to minimize heat. The size of the pit could be expanded to handle larger output of yam. Wooden racks are constructed inside the pit and yam tubers are placed on these racks for storage. On the average, the pit can take between 1500 – 2000 moderately sized tubers. The stair case compartment is covered with corrugated sheets to prevent the entry of water during rains. The structure costs between N18,800 and N27,600 and has an estimated life span of about 15 years. The maintenance cost is relatively low (about N1,100 per annum) especially when the wooden materials are treated against termites. The depreciated value amounts to about N5, 640 per annum over the life span.

Storability of Yam Tubers under the Modern Storage Structure and Traditional Yam Barn

For uniformity and consistency of results, yam tubers were purchased from the local markets, sorted to remove defective or damaged tubers and then shared among the selected farmers' barns and the new storage structure in each study location (100 tubers per barn; 200 per modern structure). Possible differences in tuber characteristics, harvest time, soil type, disease and pest infestations etc were recognized, hence the use of the above approach. Each stored tuber was identified by location, farmer and storage pit for easy monitoring and evaluation.

The results of the investigation showed that on the average about 55% of the tubers stored under the new structure remained in fairly good condition after the fifth month of storage. On the other hand, less than 20% of the tuber under the traditional system remained in good condition after the fifth month of storage (Table 1). Good condition in this context refers to the situation in which there are little or no noticeable changes in

Table 1 Storability of Yam Tubers under Modern Storage and the Traditional Yam Barn Systems.

Storage System	Proportion (%) of tubers in good condition by storage period.				
	Month 1	Month 2	Month 3	Month 4	Month 5
New Storage Structure	95	89	81	75	55
Traditional Yam Barn	87	77	61	37	19

Table 2 Storage Parameters for Yam Tubers under the Modern and Traditional Technologies.

Parameters	Beginning of Storage			End of Storage		
	Modern Sys.	Traditional Sys.		Modern Sys	Traditional Sys	
1. Average Tuber Weight (kg)	1.733	1.762	(0.35) NS	1.134	0.578	(1.660) S
2. Average Tuber Length (cm)	31.93	32.45	(-0.63) NS	27.78	27.81	(-0.04) NS
3. Average Top Diameter (cm)	26.17	25.78	(0.63) NS	21.04	19.98	(2.62) S
4. Average Mid Diameter (cm)	26.89	26.45	(0.32) NS	20.73	19.56	(2.94) S
5. Average Tail Diameter (cm)	25.21	24.92	(1.12) NS	19.14	18.49	(1.85) S
6. Average Temp (°C)*	25.82	28.88	(-19.44) S	27.04	31.37	(-14.55) S

*Note: *Varied by season; ( ) t values; S = Significant; Ns = Not Significant.*

the physical characteristics of the stored tubers, especially with regard to texture, shrinkage, and rottening. The rate of deterioration of the tubers was significantly higher in the traditional yam barn than in the new storage structure in all the locations. Beyond the fifth month (at 8th month) virtually all the tubers stored under the traditional yam barn were bad while as much as 32% of the yams stored under the modern storage system were still in fairly good condition.

There were also significant differences in such parameters as weight, length, top, middle, and tail diameters, texture and sprouting of the tubers stored under both technologies. A comparative analysis of storage parameters at the beginning and end of storage for tubers stored under both technologies is shown in Table 2.

Table 2 shows that there were significant differences in average tuber weight, tuber length, and tuber top, mid and tail diameters for tubers stored under both systems at the end of storage. In all the cases deterioration was higher under the traditional yam barn than under the modern storage system. Temperatures, which although varied by season, were significantly lower in the modern (underground) system than in the traditional yam barn. Much of the observed differences in the physical characteristics of the stored tubers could be attributed to the direct and/or indirect effects of the remarkable differences in storage temperature for which the modern storage structures had temperatures that were between 4°C to 8°C lower than those of the traditional yam barn.

Storage Losses and Values of Yam Under the Modern (underground) Storage and the Traditional Yam Barn Systems

The estimation of storage loses and values of yam in this analysis is based on 1000kg of yams stored under both systems. Table 3 shows the storage losses (kg) and values (₦) of yam under the modern storage system and the traditional yam barn. The quantity of yams lost in storage increased over time with weight losses being significantly higher under the traditional than under the new storage system.

The value of storage loss in the first month of storage was about N1,500 for the new storage system and N3,250 for the traditional barn. This was computed as the product of the loss per 1000kg and the average unit price of yam. On the average, about N3, 860 and N8,878 worth of yams were lost per 1000kg of stored yam tubers under the modern system and the traditional yam barn respectively in the second month of storage. The value of storage loss under the traditional yam barn system was about 56.5% higher than that of the new storage system in the second month of storage. Storage losses in monetary terms was 58.9% higher in the traditional yam barn than in the new storage system in the third month of storage. By the fifth month of storage, the value of storage loss was about N46,231 for

Table 3 Storage Losses (kg) and Values (₦) under the New System and the Traditional Yam Barn.

Item	Month 1		Month 2		Month 3		Month 4		Month 5	
	NS	TS	NS	TS	NS	TS	NS	TS	NS	TS
Quantity lost per 1000 (kg)	60	130	100	230	160	390	250	630	430	830
Unit price of yam (N/kg)	25.00	25.0	38.6	38.6	45.0	45.0	49.3	49.3	55.7	55.7
Total Value Lost (₦)	1.550	3,250	3,860	8,878	7,200	17,550	12,325	31,059	23,951	46,23
% Difference	53.8		56.5		58.9		60.3		48.2	

the traditional yam barn and N23,951 for the new storage system per 1000kg of yam tubers stored under the traditional system. This suggests that introduction of the new storage system will enable farmers improve on their economic returns through significant reduction in storage losses.

Determinants of Tuber Weight Loss

A multiple regression analysis was used to determine the effects of certain variables on weight loss of tubers stored under the modern and the traditional yam barn. The regression model is implicitly specified as follow:

WTL = f (TUBWT, STEMP,RH, DURS, DINF, SURF)

where

WTL	=	Weight loss of stored tuber (kg)
TUBWT	=	Tuber weight (kg)
STEMP	=	Storage temperature (°C)
RH	=	Relative humidity (%)
DURS	=	Duration of storage (weeks)
DINF	=	Degree of Tuber Infestation (index)
SURF	=	Surface factor (No). (SF = L / $(D_1 D_2 D_3)^{1/3}$)

SF = Surface Factor, L = Tuber length (m); D_1, D_2, D_3, = Top, mid and tail diameter respectively.

The regression was run separately for the modern and the traditional storage systems. The double log functional form was chosen because of greater conformity of the regression coefficients with *a priori* expectations and overall significance of the model. The results are presented as follows:

a) Modern Storage Technology

$$\log WTL = \underset{(3.11)}{\log 6.55} + \underset{(0.268)}{0.31 \log TUBWT} \quad (S.E)$$

$$+ \underset{(0.104)}{0.24 \log STEMP^*} - \underset{(0.112)}{0.39 \log RH^*}$$

$$+ \underset{(0.114)}{0.28 \log DURS^*} + \underset{(0.099)}{0.23 \text{ Log } DINF^*}$$

$$+ \underset{(0.473)}{0.32 \log SURF}$$

$R^2 = 0.81$; $F = 29.59$.

b) Traditional Yam Barn

$$\log WTL = \underset{(6.49)}{\log 13.07} + \underset{(0.219)}{0.46 \log TUBWT^*}$$

$$+ \underset{(0.119)}{0.37 \log STEMP^*} - \underset{(0.106)}{0.27 \log RH^*}$$

$$+ \underset{(0.207)}{0.43 \log DURS^*} + \underset{(0.107)}{0.32 \log DINF^*}$$

$$+ \underset{(0.513)}{0.22 \log SURF}$$

$R^2 = 0.85$; $F = 34.63$

The results above indicate that tuber weight, storage temperature, duration of storage, degree of infestation and surface factor were positively correlated with weight loss of stored tubers in both the modern and the traditional yam barn storage systems. The effect of tuber weight, however, was statistically significant in the traditional yam barn system. This could be explained by the greater exposure of stored tubers to the vagaries of weather and other environmental hazards under the traditional than the modern (underground) storage system. The effect of storage temperature on tuber weight loss was statistically significant under both systems, although the magnitude of the elasticity coefficient was higher under the traditional storage system.

Duration of storage has a statistically significant effect under both storage systems. However, the value of the elasticity coefficient was higher under the traditional than the modern storage technology, implying that there is greater storability or storage efficiency of the tubers under the latter than the former technology. The effects of the degree of infestation of the tubers on tuber weight loss were statistically significant under both systems although the magnitude of the elasticity coefficient was higher under the traditional than the modern storage system. This implies that a unit increase in the degree of infestation would result to greater weight loss of stored tuber in the traditional (0.32) than in the modern storage system (0.23). The effect of surface factor on stored tuber weight loss was not statistically significant for both storage systems. Relative humidity had an inverse correlation with weight loss of stored tuber under both systems and the effect was statistically significant.

The effects of such biological (tuber infestation, duration of storage, surface factor and tuber weight) and climatic (temperature and relative humidity) factors on storability of yam tubers under the modern (underground) and the traditional yam barn technologies have been established. With the exception of surface factor, the other variables exhibited statistically significant effects on weight loss of stored tubers. The explanatory variables jointly explained about 81 per cent of total variation in weight loss of stored tubers under the modern storage system and 85 per cent under the traditional yam barn system.

Economic Benefits of Yam tuber storage under the modern and traditional system

The element of opportunity cost was taken into consideration in determining the economic benefits derivable from use of the modern storage system. The net weight gains per 1000 kg of stored tubers in the modern storage system over the traditional yam barn system were determined per month and used in the estimation of total value saved in both physical quantities and monetary terms. This approach, however, does not represent an exhaustive treatment of cost-returns analysis of the storage systems, but rather presents in a simplistic manner the short-term net benefits of the modern storage system over the traditional yam barn system.

Table 4 shows the net gains of the new storage technology over the traditional yam barn system. The table shows that the yam farmers would save about 70 kg of yams valued at N1,750 by storing 1000 kg of yams under the modern system than under the traditional yam barn in the first month of storage. About 130 kg of yams valued at N5.018 would be saved in the second month by storing 1000 kg of yams under the new system than under the traditional yam barn. By the fifth month farmers would save on the average, about 400 kg of yams valued at about N22,280 from 1000 kg of yams stored under the new storage (underground) system.

When the cost of materials and their depreciated values (N5,640/year) are taken into consideration a net benefit of about N38,920 will be realised by the farmer from storing 2000 kg (4 lines) of yam tubers over a 5-month period using the modern storage structure. This also shows that the costs of the structure would be offset by the net gains within a period of one year. Moreover, the net benefit would be significantly higher if the full storage potentials of the new storage system are exploited especially in terms of duration. It was observed in the survey years that most of the yams put into storage were used at between two to four months after harvest. It is estimated that the new storage system would effectively store yam tubers for over eight months with a reasonable proportion of the tubers remaining in a fairly good condition at the end of the period. This would significantly increase farmers' net benefits as such tubers would attract remarkably higher prices at later periods of storage. This has potentials for large scale commercialisation by both yam farmers and dealers on yam.

Table 4: Net Gains of Modern Yam Storage Technology over Traditional Yam Barn System.

Item	Month 1	Month 2	Month 3	Month 4	Month 5
Net Wt gain per 1000 kg of tuber (kg)	70	130	230	380	400
Unit price (N/kg)	25.00	38.60	45.00	49.30	55.70
Total value (N)	1,750	5,018	10,350	18,734	22,280

SUMMARY AND CONCLUSION

The new yam tuber storage technology has been developed and the performance assessed at the small holder farmers' level in southeastern Nigerian. A total of fifty -five yam farmers were randomly selected from eleven communities for the study. Data were generated from stored yam tubers in eleven underground storage structures and fifty five traditional yam barns in addition to the questionnaire administered to the selected farmers.

The result of the study showed that the new storage system is technically and functionally more efficient than the traditional yam barn system. The results, for instance, indicate that an average of about 55% of the tubers stored under the new structure remained in fairly good condition after the fifth month of storage, while less than 20% of the tubers stored under the traditional yam barn remained in good condition after the fifth month. Rate of deterioration was significantly higher under the traditional yam barn than under the new storage system. The value of storage loss was about N46,231.00 for the traditional yam barn and only N23.951.00 for the new storage system per 1000 kg of yam tubers stored. Hence, the value of storage losses under the traditional yam barn was about 55% higher than under the new storage system.

The major determinants of the tuber weight loss under both storage systems were identified to include tuber weight, storage temperature, relative humidity, duration of storage and degree of tuber infestation. The economic benefits of the new storage system were also analyzed. The results indicate that by the fifth month of storage, farmers would save, on the average, about 400 kg of yams valued at about N22, 280.00 from storing 1000 kg of yams under the new (underground) storage system. When the costs of materials and their depreciated values as well as the average storage potentials/capacity are taken into consideration, a net benefit of about N38, 920.00 will be realised by the farmer from storing 2000 kg of yam tubers over a 5-month period using the new storage system. Thus, the net benefits will offset the costs of the new storage structure in the first year, all things being equal. Moreover, the net benefits would be significantly higher if the full storage potentials of the storage systems are exploited especially in terms of duration of storage. It is estimated that the new storage system would effectively store yams for over eight months. This would significantly increase farmers' net benefits as such stored tubers would attract remarkably higher prices at later periods of storage. Hence, introduction of the new storage system will enable farmers improve on their economic returns through significant reduction in storage losses.

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