EVALUATION OF TUBER STORAGE STRUCTURE AND METHODS IN MIDDLE BELT OF NIGERIA (KWARA AND BENUE STATES)

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NIGER STATE

NOVEMBER, 2004.

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BEING A PROJECT REPORT SUBMITTED TO DEPARTMENT OF AGRICUALTURAL ENGINEERING.IN PATIAL FULFILMENT FOR THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) IN AGRICULTURAL ENGINEERING, SCHOOL OF ENGNEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNVERSITY OF TECHNOLOGY MINNA, NIGER STATE NIGERIA.

NOVEMBER, 2004.

DEDICATION

This project is dedicated to my parent, Mr. / Mrs. EZEKIEL & OMOLADUN RACHEL KEHINDE.

You made it possible for me to tread the path you were not opportune to tread.

DECLARATION

I hereby declared that this thesis is an original work of me, and has never been presented elsewhere for the award of any degree. Information derived from published work of others has been acknowledged in the text.

..... 06-12-2004.....

SIGNATURE OF STUDENT DATE

The above declaration is confirmed

....

DR (MRS) Z.O. OSUNDE DATE

CERTIFICATION

The undersigned certify that they have read and recommended to the school of Engineering and Engineering Technology for acceptance, a thesis titled "EVALUATION OF TUBER STORAGE STRUCTURES AND METHOD IN MIDDLE BELT OF NIGERIA (KWARA AND BENUE STATES)" submitted by KEHINDE, SAMUEL OLADELE in partial fulfillment of the requirements for the award of the Bachelor Engineering Degree.

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EXTERNAL EXAMINER DATE

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ABSTRACT

Roots and tubers form the major types of crops grown in middle belt of Nigeria (Kwara and Benue States).This project reviews the various methods of storing roots and tuber crops (cassava, yam, sweet potato and cocoyam).Estimation of the extent of damage during storage from different sources is a basic requirement for production and storage planning strategies.

A survey was carried out in five and six of the sixteen and twenty three local government areas of Kwara and Benue state respectively.Some villages from the local government were randomly selected as regards roots and tuber producing areas to estimate losses during storage by administering questionnaire and personal communication during field trips .The questionnaires were administered to a total of one hundred and twenty people respondents covering mostly small scale farmers and traders who are in root and tuber business .In addition ,interview were conducted out randomly.

The study revealed the distribution of different storage methods and structures i.e. yam barn, hut storage, warehouse and pit storage .Projections were made from the study which showed that yam is the most widely root and tuber grown ,followed by cassava ,sweet potato and cocoyam .Major losses include rodent attacks ,fungi infection, insect attack ,moulding /rotting ,mechanical damage and thieves. Yam barn and hut storage methods are the most predominant storage structures used in Kwara and Benue State respectively.

CHAPTER ONE

1.0 INTRODUCTION

The root and tuber crops collectively are the largest single source of calories for the population of the humid and sub humid of west and central Africa. Cassava (manihot esculent crants) is the most important of these crops in terms of total production in Africa, but yam (Dioscorea spp ,sweet potato-ipomoea batatas-,and cocoyam-colocasia spp. And xánthosoma spp.) are each the dominant root crop in some regions. (Dorosh, 1988).

Generally the roots and tuber crops require cool temperatures but higher levels of humid during storage .Although they are much more susceptible to moulds and other organisms because of their high moisture content.

1.1 GENERAL CONSIDERATION

Cassava is a perennial woody shrub, usually propagated by planting a cutting taken from the woody part of the stem .The roots are typically harvested nine to fifteen months after planting .Al though some cultivars may be left unharvested for two to three years. The plant cannot waterlogged soils but is very tolerant of drought once established. It however differs from the other major root crop not appears to have a natural function in the preservation of plant through the dry season (Pamela et al ,1984)

Yams is an annual crop and important part of the staple diet .It is a source of carbohydrates, proteins and vitamins (Adesuyi,1977).More over they are an important part of traditional culture ,religion and for many people there is a strong emosional attachment of the crop .They are grown in an area of fairly high rainfall with a distinct dry season of not more than five months. Small yams or pieces of yams called setts are planted as seeds yams,

often in mounds or ridges of soil, and most yams are harvested seven to nine months after planting (Dorosh, 1988)"

The sweet potato is a perennial plant but is usually grown as an annual crop and is vegetative propagated form stem cuttings taken from growing plants .The growing period is normally three to seven months depending on the environment and cultivar .They are adapted to a wide range of soils and has a good drought tolerance but cannot tolerate water logging (Hahn and Hozyo, 1984)"

The last but not the least, the name cocoyam in West Africa is used to describe both colocasia and Xanthosama although "old" cocoyam is sometimes used for the former and "new" cocoyam for the latter .Xanthosoma was introduced to West Africa recently and is ready for harvest between nine and twelve months after planting (Onwueme ,1974).The edible portion of the plant is a corm – a group of small corms of comels -found largely or entirely under ground. They require a large amount of moisture with rainfall greater than 2000mm per year for the best yields. The leaves of several species are eaten as green vegetables (Pamela et. al.,1984).

1.2 TUBER STORAGE AND STORAGE LOSSES

Roots and tuber crops are stored for two reasons; to preserve planting material for next years crops and to preserve their tubers destined to be used for food .The consequences of the losses in tuber production cannot be over emphasized. They reduced economic return for farmers, traders and the state .It is clearly desirable that such amount of losses be minimized if they cannot be completely eliminated. These storage losses include sprouting,

rotting physiological changes (i.e. the rate of respiration) biological factors the initial quality of the tubers to be stored atmospheric and lack of appropriate storage facilities.

1.3 OBJECTIVES OF THE STUDY

This research work is carried out to achieve the following aims.

a) Identification and evaluation of the different storage methods performance in the state.

b) Estimation of the quantity of tuber lost annually during storage.

1.4 JUSTIFICATION

It has been observed that there is high loss root and tuber crops in storage. This loss limits its availability as regards sales consumption and even during the planting season .Over the years different causes of storage looses in root and tuber have been identified .For this reason it is necessary and advantageous the ascertain the right storage atmosphere that will minimize or eliminate these losses after harvesting.

However there is need to continue to examine present techniques and strategies with a view to identifying problem areas and suggesting possible solutions to them. In this lies the justification of this study.

1.5 SCOPE AND LIMITATIONS

The scope of this study is to assess in storage structure of root and tuber crops and equally identify the sources of losses. The roots and tubers crops under review are cassava ,yam, sweet potato and cocoyam .The research work is to cover the middle belt of Nigeria with Kwara and Benue states .The former comprising of Oke-Ero ,Ekiti, Irepodun, Offa and Oyun ; five local government areas respectively.While, the latter cover six local government areas of Ukum, Katsina-Ala, Vandeikya,Gwer, Adol, and okpokwu respectively.

LIMITATIONS

Ignorance: The attitude of the people towards the completion of questionnaire and responding to questions asked from them during the interview was a major problem. This was because the people were reluctant in answering question for fear of the author being probably government agent whose aim is to expose them to tax collections.

Language Barrier: This was another problem in administering the questionnaire, an interpreter was needed to carry out on- the- spot translation.

Finance: Costly project in terms of transportation, accommodation, feeding and photographs of relevant storage structures during field trips.

Illiteracy: Most peasant farmers are not well educated that is if educated all and as such do not pass across reasonable information concerning the project. Lack of across to the remote

parts of the local government areas visited was also very difficult as one would have to walk distance due to the fact that buses seldom go there.

Lack of Computer processing facilities: This includes inavailability of computer and printer and also lack of computer processing soft wares as this affected data processing.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 WHY STORAGE

Storage as defined by Ajisegiri (1987) is the setting aside for future use of separable items". A major concern of man is assurance of food supply at all seasons .Some products are stored until a time when the market forces are favorable for sale or are stored waiting for transportation. No matter how crude these methods are, changes can only be achieved when farmers believe in the "new ideas" as being better their existing practices (Ajisegiri et.al. ,1992)

Storage is carried out in order to balance periods of plenty against periods of scarcity and make products available for the whole year round .The farmer stores his products at the period of harvest so that when the products is scarce he can command high financial returns for profit.

2.2 SOURCES OF STORAGE LOSSES

The factors that enhance deterioration and thus lead to losses in agricultural crops can be grouped as followings.

2.2.1 PHYSIOLOGICAL FACTORS

Harvested root and tuber crops still carry on metabolic processes during storage.One of these processes is respiration (cassava root is an exception) which result in loss of water and dry matter.(Nnodu et al ,1987)

Bouton (1966) showed that respiratory processes in stored potatoes make definite contributions to storage loss. He reported a 12% loss in dry matter from potatoes stored at 10 c during the first month. Passam, et. Al., 1978 reported that respiration in dormant yam tubers stored at 35° C contributed 10% of the total weight loss stored.Sprouting is another source of physiological loss. Stored carbohydrates are used up during termination of dormancy in forming sprouts. Adesuyi (1975) reported a total loss of 22.4% starch in yam whose sprouts were not removed.

There is however occurrence of changes in chemical composition of the stored product for instance vascular streaking in cassava and Starch sugar equilibrium changes .It renders the tubers unacceptable because of blue black to brown discoloration of the vascular tissues and subsequent softening of the tissues that follow .Increase in sugar content of potato tuber during storage at low temperature result in dark 'coloured chips during processing into chips.

2.22 PHYSICAL FACTOR

It deals with handling of the harvested crop, transportation and storing. During harvesting of roots and tubers, a lot of wounds and bruise are inflicted on the tubers due to rough handling .The wounds and bruises provide avenue through which destructive pathogens enter the tuber.(Couresy and Booth 1972).A reasonable quantity of stored roots and tuber owe the reduction of their storage life to these damages and this damages causes an economic loss to the farmers (Umeh, 1987)

Extreme of temperature could also cause physical damage to stored roots and tuber. Yam stored at temperature of 12 c or below suffered chilling injury resulting in internal discoloration and decay (Agboola, 1982).Low temperature injury has also been reported in

sweet potato and cocoyams.High storage temperature increase the rate of metabolics activities resulting in high respiratory loss of carbohydrates.

2.2.3 EXOGENOUS FACTORS

This include biological variety of insects ,pests, nematode, rodents, bacteria, fungi and rot on the stored produce(Wilson, 1980).Rottening is the damage done to stored root and tuber crops by the microbiological infestation or decay to adverse weather condition (intense heat from the sun and heavy rainfall) if they are protected .Two types of rot that occur in tuber generally during storage ; physiological rot and microbiological rot .The latter has the effect of increases the rate of weight loss respiration leading to loss of dry matter ,it affects the viability of the tubers.

2.3 TUBER STORAGE PROBLEMS

Deterioration is any form of loss in quantity and quality. (Greig and Reeves, 1985)The cause of deterioration in stored products include;

2.3.1 Rodents And Mammals

When root crops are not properly secured during storage, they are attacked by rodents and mammals .These rodents enter the store and eat some of the stored produce .In

some cases they eat a very reasonable quantity of the produce that what left is not fit or worth selling .Damages done by them expose the crops to rot –causing organism.(Nnodu et al 1987)

While root and tubers left unharvested on the field as a means of storage suffered serious damages caused by animals like grass cutters, goats, pigs etc which feed on them. Monkeys and man were known to pilfer stored products from barns located close to the forest.

2.3.2 Nematode Attack

Nematode contribute to the post-harvest losses root crops, especially yam. The most important nematode in yams is scutellonema bradys. This is because,it is the only specie that persist in stored tubers.

Scutellonema bradys is a uniform nematode measuring up to 1mm in length .It has a well developed, stout, stylet for puncturing cells and withdrawing sap .Sexes are separate and remain wormlike. The life cycle is simple, eggs are laid in the soil or on root and tuber within 21days larvae develop into mature adult .All active stages of the life cycle are in fective.

It is widely distributed in the tropics especially in areas where yam is grown. This is a major field and storage pest; the severity of attacks varies with locality, yam species and cultivars. It invades the primary roots growing from the rhizomatous head of the tuber through the damaged areas and cracks on the surface of the tubers where it then moves inner and intra-cellular in the tissue ,disrupt and empty the yam cells.

2.33 INSECTS

Most insects that causes damage to roots crops in storage do not originate there, but such are carry over from field infestations.In yams and cocoyam which are sometimes stored by heaping them on the ground ,termites destroy the tubers. Yam beetles,Heteroligus and prionoryctes spp are pre harvest pests but the wounds they inflict on the tubers during their feeding predispose the produce to rotting during storage.Scale insects Aspidiella bartii and mealybugs-coccidea-do infest stored yams and reduce their viability .Sweet potato weevil, cylàs spp is another one that can destroy the whole lot of stored potatoes once they infest. Infestation starts from the field and damage gets worse in storage (umeh 1987)

Insects are also known to cause serious losses when they attack stored processed root and tuber products. They feed on the products and contaminate it with their faecal waste thereby it use less economically (Umeh, 1987)

2.3.4 Yam Storage Beetles

Adults are small- sized beetles 3.0 to 4.5 mm long, dark grey to dark brown in colour, very active and generally very difficult to capture. Their colouration blends well with the environment making detection difficult.Arae fasciculatus (Degeer] appears to be the most important amongst others.

Eggs are inserted into the host yam tuber in storage .All the development stages take place internally and the adult emerges leaving an emergence hole on the tuber or other processed forms of yams e.g. dried yam crops(Mphuru ,1974)

It infests yam tubers and process forms of yams.Wounded or bruised tubers –those damaged during harvesting- are preferred. Severe infestation results in the total loss of yam tubers and chips (Emchute and Echendu 1992)

2.4 STORAGE TECHNIQUES OF YAM

2.4.1 Barn Storage

In most West African countries the most common and widely used method of storing is the yam barn. It is made from vertical wooden poles of about 3m height. The required capacity of this structure determines the number of poles to be used .These poles can be obtained from bamboo and strong wood (Adejumo 1992).The barn is usually constructed in an open and well ventilated place (Nnodu et. al., 1987).Shade is provided by potage of live sticks used in constructing the barn. They spaced about 1m apart along the circumference of the barn to provide structural rigidity for the entire barn and also protect the yam tubers from the direct rays of the sun .(Nnodu ,1983).

The vertical poles are held together by more rigid horizontal sticks which could be bamboo .The yam tubers are placed horizontally and tied to the vertical poles of the barn one above the other along the height of the pole.

The structure has the following advantages: The technology of construction is simple. it is cheap because of the readily availability of the materials of construction, the method is effective during the dry season, the tubers are provided with adequate ventilation and it is easy to inspect the barn and pick out deteriorating tubers .Termite damages are reduced due to the use of live poles (Coursey, 1966).It's disadvantages are that :both time and efforts are wasted because the fragile vertical poles need to be replaced leading to repeated labour ,stealing is common and rottening of the barn framework and the yam tubers due to the moist environment (Adejumo ,1992).

2.4.2 Clamp Or Pit Storage

This structure is common with the private farmers. The construction of the pit is done by using diggers and hoe. The diameter vary from one place to another but it ranges between 2 to 4m with a depth of about 4 to 5m.In some cases the bottom of the pits is lined with dry grasses before piling the yams in them. Although before lining with grasses small stones were used to line the base of the pit up to 0.5m above the base for pits deeper than 2m .This was done to ensure that if water entered from the base it would not get to the yams. Then , another layer of dry grasses is placed on the produce before finally covering with soil .Sometimes a shelter is built over the pit to keep off rain or flood .Flooding, sprouting ,termite attack and difficulty of inspection to remove rotten tubers are some of the problems encountered with this methods of storage (Nnodu et. al., 1987)

The advantages are :temperature variation is very low, insect infestations is restricted by low level of oxygen ,the technology of construction is very simple it is cheap as there is little or no skill required and there is no risk of fire (Adejumo ,1992) .These structures have been used in areas where the water table is low and the soil is stable to store different crops ranging grains to tubers (Hall et. al .,1966)

2.4.3 Underground Storage

This storage is simply meant by leaving the tubers in the ground during the dry season until they are required for food or sale .In this method the yam tubers will stay without appreciable loss of quality. This system of storage has many advantages .The practice exposes the tubers unnecessarily to attack by such pests as beetles, termites, rodents, pigs, monkeys, thieves (human beings) and nematodes. When the ground becomes baked due to

dry season condition, harvesting becomes difficult while if heavy rain or flooding occurs the tubers may become rotten.[Umeh,1987]

2.4.4 Storage In Insulated Building

The method involves the construction of a house with the roof ceiled internally ,an automatic evaporative cooling and heating system is installed with differential thermostat and humidistat which gives good control of temperature humidity and ventilation. The tubers are packed in the house with the manipulation of this system, the tubers can maintain palatability for about a period of six months of storage .Adesuyi [1977] found that 15 c suppressed sprouting in stored yams for six months.

2.5 STORAGE OF CASSAVA

2.5.1 Underground Storage

Traditionally, due to its rate of spoilage after harvested, cassava of matured root and tubers are left in the ground unharvested until needed for food or sale. At times if it is harvested it's immediately used or processed into a dried product such as gari and fufu with a longer storage life.Sprouting, rodents and pest attack tubers becoming fibrous and tying down of agricultural lands which will otherwise have been used for other crops or purposes are some of the problems associated with this method of storage.(Nnodu et. al., 1987).There is decrease in the economic output of the land and increase in pressure on the land .Consequently the crops starch content and as suitability for many food preparation decline (IITA. Ibadan :A reference manual 1990).

2.5.2 Box Storage

This method involves the construction of a wooded box to any convenient size with sides perforated. Moist saw dust are packed in the box and the tubers inside .The box is stored in the room at room temperature with high humidity .Storage at temperature between 25 and 40 c and high relative humidity can allow storage for 4 to 8 weeks (Booth ,1973)

2.5.3 Clamp Storage

Clamps are constructed by placing the roots in cone shaped heaps and covering them with straw and soil but at the same time providing a little ventilation through a pipe is placed at the top most part of the construction .This method of storage can provide a storage life for over two weeks (Booth, 1978)

Trials on this methods have indicated that conditions conducive to both curing and storage can also be obtained in these units provided internal clamp temperature remain below 40 c and roots are prevented from drying out (Booth ,1973)

The methods allows for larger scale storage of cassava than the box method mentioned above. If this technique is widely applied it will help in reducing considerable pressure on land use in pieces where traditional method are used in root storage .The disadvantage of this system is that the stored roots may be destroyed by flooding or attack by termites.

2.6 IMPROVED STORAGE STRUCTURE

2.6.1 Improved Yam Barn

This structure is an improvement over the traditional yam barn. It is a rooted storage barn with racks for spreading out the tubers .The sides of the barn have a wall one meter

high while the remaining portions are covered with wire mesh to keep off rodents and allow proper ventilation.Thetubers spread out in racks inside the barn instead of the laborious tying with twine as in the case in traditional yam barn. The root over the shade protects the tubers from excessive sunshine and splaching rain.[Agbo-ola, 1982]

2.6.2 Storage And Moist Saw Dust

This involves placing freshly harvested tubers in moist saw dust (67% moisture content) contained in boxes or baskets .The moist saw dust prevents desiccation of the produce as well as preventing bio-deterioration .This methods has been successfully used to store cassava tubers for 8weeks (Okpugo et. al., 1972),sweet potato tubers for 4 months/(Nnodu 1983) and ginger for 6 months (Okwowulu and Nnodu, 1986) .Cassava tubers stored in saw dust must be freshly harvested with 15 – 20 cm of the stem attached. The three types of containers which can be used for this method are woven baskets, paper carton and wooden boxes with covers. In this way with layers of saw dust followed by layers of fresh cassava tuber, carefully arranged so that the tubers do not touch each other. That is, saw dust is packed between the tubers and also at the top of the container and is then moistened.the containers can be transported or stored in this way. It is essential in this type of storage to inspect cartons every 3 days to ensure that the harvested tubers have no damage as this method is suitable only for storing under damaged tubers.

2.6.3 Other Forms Of Cassava Storage

Among the improved storage methods of fresh cassava are those based on techniques involving freezing, gamma, irradiation, control storage environment (relative humidity and

temperature) and waxing .However, none of these techniques have been sufficiently tested.Three improved storage methods which have undergone sufficient testing, including field testing are

i. Dipping fresh tubers in fungicide and packing them in polythene bags

ii. Storing them in specially prepared trenches and

iii. Storing them in moist saw-dust

STORAGE IN POLYTHENE BAGS

This method appears to be the simplest way of storing tubers if properly conducted, it ensures a shelf life of 2 weeks or more. The method is based on the principle of "curing"- the capacity of the tuber to form a new layer of cells over damaged tissues .Freshly harvested roots are treated with 0.4% solution of mertectathrabendazole base fungicide. They are then packed in polythene bags and sealed.

STORAGE IN TRENCHES

This low cost method developed by the Nigeria stored products research institute (NSPRI) keeps cassava fresh for at least 6 to 8 weeks and can be implemented easily by farmers and processors. A trench is dug in the ground at a site which has low water table .The trench should be 2m long ,1.5m wide and 1m deep .Depending on the size of the tubers a trench of this size can store from 05 to 0.7 tons of cassava.

A shed made of wood and iron or bamboo with a thatched roof is constructed over the trench .It is economical to make several trenches under the same shade. This method is sometimes similar to the underground pit storage method.

STORAGE AND MOIST SAW DUST

This involves placing freshly harvested tubers in moist saw dust (67% moisture content) contained in boxes or baskets .The moist saw dust prevents desiccation of the produce as well as preventing bio-deterioration .This methods has been successfully used to store cassava tubers for 8weeks (Okpugo et.al.,1972),sweet potato tubers for 4 months(Nnodu 1983) and ginger for 6 months (Okwowulu and Nnodu 1986) .Cassava tubers stored in saw dust must be freshly harvested with 15 – 20 cm of the stem attached. The three types of containers which can be used for this method are woven baskets, paper carton and wooden boxes with covers. In this way with layers of saw dust followed by layers of fresh cassava tubers, carefully arranged so that the tubers do not touch each other. That is, saw- dust is then moistened, the containers can be transported or stored in this way .It is essential in this type of storage to inspect cartons every 3 days to ensure that the harvested tubers have no damage as this method is suitable only for storing under damaged tubers.

2.7 IMPROVED STORAGE TECHNIQUES

Traditional storage may be improved upon by incorporation of several relatively simple kinds of treatment. This however extends storage life at fairly low-cost and with low risks .It includes; curing, careful handling, chemical.,etc

2.7.1 Curing Treatment

To reduce post harvest infections which does not require elaborate apparatus or harmful chemicals, is curing. Since wounding and bruising cannot be avoided due to our harvesting and handling methods, curing the tubers before storage should be employed to reduce the incidence and spread of rot causing organism as well checking excessive evaporation. Curing is wound healing process.

Tubers are exposed for short periods to high temperature and humidity to promote wound healing through suberization and periderm formation. The new cork layer formed, helps to prevent loss of water and entry of pathogens.

TABLE 1 CONDITIONS REQUIRED FOR CURING ROOT AND TUBER CROPS

CROP	TEMPERATURE (C)	RELATIVE HUMIDITY (%)	TIME (DAYS)
Cassava	30 – 35	80 – 95	4-7
Yams	32 – 40	90 – 95	1-4
Sweet Potatoes	30 – 32	85 – 90	4-7
Coco yams	32 - 35	95 – 100	3-5

Source ; Booth, [1974])

Curing has been used in Nigeria to reduce storage losses in yam (Adesuyi, 1973) and sweet potatoes (NRCRI, 1981) .Losses due to disease were less than 2% in cured tubers in comparison with about 10% in uncured tubers (passum et. al. ,1976)

2.7.2 Careful Handling

Since roots and tubers are bulky, they are prone to bruising and wounding during harvesting and handing .This breaking of the skin provides avenues for the entry of pathogens as well as stimulating physiological deterioration and dehydration careful handling to minimize mechanical injury with considerably reduce storage losses .Booth, (1972) reported that transporting yams in cartons instead of stacking them in lorries reduced the percentage injected for export from 49.7% to 16.5%

Other ways of reducing mechanical damage are harvesting when the soil is moist to reduce bruising, sorting out badly damaged tubers before storage and reducing the number of times the tubers are handled before final disposal (Ene, 1987).

2.7.3 CHEMICAL TREATMENT

Chemicals are used for the control of post-harvest infection and damage by micro-organism, rodents and other pest where cultural practices prove ineffective. The chemicals have been used either as sprays, dips ,fumigants or in treating wraps for example maliec hydrazide (MH) which when applied as pre-harvest foliar spray three weeks before harvest reduced sprouting in yams for 4 months (Haywood and Walker,1961)

Fungicides that have been used in Nigeria to control decay of stored roots tuber crops are sodium orthophanyi phenet. Bentate. Boric acid .Thiabendazole (TB2). captain. Borax. line sodium hypochlorate (Bleach) and wood ash (Coursey and Booth .1972:Booth .1978:Nnodu and Nwankiti. 1986:Adesuyi.1977).

It is important that chemicals used for treating foodstuffs be used properly according to directions. It is also important that such chemicals be cleared and registered for use on the particular commodity by competent authorities for safety purposes.

2.7.4 Sanitation

Storage houses are thoroughly cleaned out before produce is put in to prevent carry over of infections. Washing of floors and walls with disinfectants should be carried out. Debris of the old crop left in the storage house should be disposed of properly to avoid being sources of successive infections. Equipment used for handling harvested produce must be in good sanitary condition.

2.7.5 Processing

Food processing is a method of preservation. Processing of roots and tubers into other food forms with longer shelf life could play a very vital role. It should be processed immediately after harvest to reduce contamination by insects and other micro-organisms as this would affect the quality and storage ability of the finished product .As a result of the combination of a high degree of perishability, bulkiness, distance from production areas to consuming centers and the seasonal nature attention has focused on the processing of the tubers into chip and flour.

CASSAVA CHIP AND FLOUR

The process is normally carried out by soaking the unpeeled roots in running water, i.e. streams, although stagnant water can also used for 3 to 4 days .During which some fermentation may occur when soft the roots are removed and peeled.It then crumbled by hand ,dry by sun-drying result into cassava flour. While cassava chips be processed by parboiling them after peeled and then drying[sun-drying]. Drying generally takes 3-10 days although only 1 or 2 days is suffient in ideal conditions and once dry, the chips can be stored for 3-6months (Oke, 1965).These dried chips can then be grounded into flour when needed which is known as Lafun, an important staple foodstuff among the Yoruba of western Nigeria.

YAM FLOUR

It is used as a way of utilizing tubers that are not fit for storage especially i.e mishappen, damaged or partial decay yams .Yam flour is prepared by cutting the tuber into slices of about 1cm thickness, peeling the slices and sun drying them. Slices may be boiled or parboiled before sun drying to soften the tissues giving a more palatable product. The process of drying may take several days depending on climatic conditions. As traditional made yam flour has a high moisture content (14 -18 %) and is normally packed in jute bags for the purpose of distribution and marketing, a condition that allows for the entry of water vapour and pests (Adesuyi, 1973)

In Nigeria, yams are processed into various foods farms which include pounded yam from (D.Rotundata and sometimes D.Cayenesis),boiled yam ,roasted yam, fried yam slices and yam balls, meshed yam, yam chips, yam flakes and yam flour as a result of peeled,chipped, dried and milled into a flour .This flour is cooked in boiling water and turned into a thick paste similar to fufu and eaten with soup. Pounded yam, however, is by

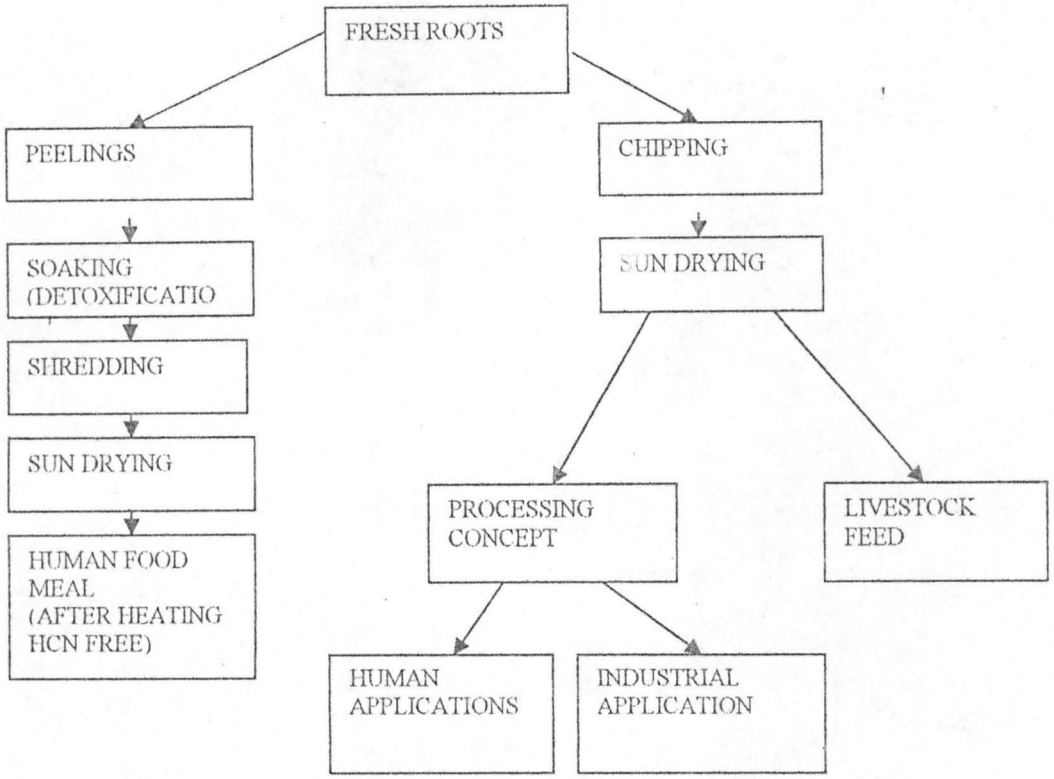
far the most popular food from yams ,it is still the food for royalty, special guest and festive occasions(Hahn et. al., 1987)

The simplest technique used to prepare cassava for immediate consumption are boiling ,roasting and baking .It can be processed into cassava flour, gari ,fufu ,cassava chips and starch.

For the processing into gari the fresh tuber is peeled, washed and grated .The pulp is then collected and packed in a Hessian bag. This bag is pressed down either mechanically or in traditional form by use of stones or other heavy materials for about 3 days .During this process moisture is lost and some hydrogen cyanide is eliminated by setting for a fermentation process. The pulp is sifted to remove the coarse fibers and leave the starch or gari which is latter heat dried (fried) with constant stirring .Any hydrogen cyanide left behind is virtually destroyed .To produce the yellow type of gari a little palm oil is added during frying to give it the characteristics yellow colour (NSPRI, 1983)

Fufu can be prepared by boiling or streaming peeled cassava roots and then pounding them in a wooden pestle and mortal until a homogenous paste is obtained which is eaten with soups or stew of meat or fish (Affran ,1968).In some area the roots may be soaked, unpeeled for about 5 days before drying.

FIGURE 1,ALTERNATIVE CASSAVA PROCESSING ROUTES



Sweet potato are prepared for consumption by simply scrapped the tubers and sun -dryied .This is done by first soaking and mashing with warm water or roots from storage pits are oven cooked and then dried The tubers are generally being prepared for consumption by boiling, streaming, baking or frying.(Yen, 1974)

Finally, cocoyam can be processed into poi. Corms are first baked, peeled and pounded with a stone pestle in a long shallowly hollowed- out board or store .Water is added gradually until the correct consistency is obtained after which the dough is placed in a calabash and left to ferment for several days (varied according to tastes)for immediate consumption aroid corms are normally boiled ,baked, roasted or fried (Greenwell, 1967).

CHAPTER THREE

3.0 METHODOLOGY

This report is a survey work, which involves data collection through questionnaire administration and oral interview. Two states known for their tuber production in the middle belt region of Nigeria were selected for the survey work. These states are Kwara and Benue. Five LGA out of sixteen LGA in Kwara and twenty – three LGA in Benue State were randomly selected for the survey. The selected LGA'S are Oke –Ero, Ekiti ,Irepodun ,Offa and Oyun in Kwara state and Ukum, Katsina –Ala, Gwer ,Ador, Okpokwu and Vandeikya in Benue state. A total of thirty six villages were visited and two hundred and twenty persons interviewed comprising of farmers, traders and agricultural workers .

Table 2 shows the states, LGA selected number of villages visited and number of people interviewed.

SAMPLE METHOD AND SIZE IN EACH LOCAL GOVERNEMT AREA

STATE	LGA	NO OF VILLAGES VISITED	NO OF PEOPLE INTERVIEWED
KWARA	OKE – ERO	6	20
	EKITI	4	16
	IREPODUN	3	24
	OFFA	4	18
	OYUN	2	22
BENUE	UKUM	3	22
	KATSINA – ALA	2	18
	GWER	3	15
	ADOR	3	25
	OKPOKWU	2	16
	VANDEIKYA	4	24
TOTAL	11	36	220

In this way, two different survey methods were adopted .The first was by the use of personal interview of the farmers by the authors and the second was by questionnaires administered to farmers /yams traders, ADP workers, state Ministry and Natural resources workers.

In addition to these visual observation of the storage structure used for tubers in the area visited was made .Photographs of relevant storage structures were taken .The choice of the LGA's for this work was based on their root tuber production capacity.

3.1 METHODS OF DATA COLLECTION AND QUESTIONAIRE ADMINISTRATION

In this way , two different survey methods were adopted .The first was by the use of personal interview of the farmers and the second was by questionnaires administered to farmers /yams traders. In addition to these visual observation of the storage structures used for tubers in the area visited was made .The choice of the LGA's was based on their root tuber product capacity.

In each local government Area, some traders involved in root and tubers crop marketing were interviewed .The traders were randomly selected on a market day for the interviewed, for example during the yam market days of Zaki – Biam in Ukum LGA of Benue state,with a row of tuber sellers, the pattern followed was , the first seller was interviewed, then the fourth, the eight person and so on .The LGA and the villages in each LGA inclusive using the map of the state. Provision was made for villages that were not indicated in the map through enquiry. This ensured a good coverage of the total area .The same process was followed for the market days of Odo–Owa in Oke–Ero LGA of Kwara state (which comes every five days)

More also, in each village visited, a number of farm household were randomly selected for the interviewed .In selecting the farmers for interviewed the methods used was that, two adjacent houses were picked along a street, then another set of houses were picked after a specific block of houses. Depending on the population of the village, care was taken to ensure good distribution of sample over space.

In addition to farmers and traders interviewed, Government establishment involved in agricultural production were visited .

The visited government establishments are ;

A. Kwara and Benue states ministry of agriculture and Natural resources state headquarters in Ilorin and Makurdi and LGA offices.
B. Kwara and Benue states Agricultural Development Project (ADP) in Ilorin and Makurdi.
C. Nigeria stored product Research Institute (NSPRI) Ilorin.

In these Government Parastatals, the persons interviewed include: ADP offices: State's Director of federal Department of Agriculture: State boards for Agricultural land, Development Authority and Agricultural Engineers.

The information requested in the questionnaire was divided into four sections. These are

1. General information
2. Tuber production
3. Tuber storage method
4. Method of processing

Other vital information contained in the questionnaire administered include storage structures available for storing root and tuber crops storage,methods and problem associated with their uses. Respondents (farmers and tuber traders) who were lliterate filled out the questionnaire. The illiterate ones were helped to filled the questionnaire based on responsed from them as regards the question under the author's supervision.

The questionnaire were carefully distributed to the farmers and traders for easy administration throughout the eleven local government areas of the states .Quite a reasonable numbers of people were interviewed during the survey work ,in all the local government areas covered . During the interviewed,the various storage methods and structures were carefully observed.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

The questionnaire was therefore interpreted based on the information collected with the result of the study presented with particular group of questions .From the responses gathered in this study, farmers have being into tuber production for a long time .The family size of the respondents ranges from about five to nine but with an average of seven people .Family in this study comprises the nuclear and extended members .The minimum years of farmers in production in Kwara and Benue states is about 20 years while the maximum is about 60 years .

Year into tuber production in this study is defined as average minimum and maximum number of years respondents have been growing tubers as a main crop .

The Yoruba and the Tiv people are the predominate tuber producing farmers in the state of Kwara and Benue respectively .Age of respondents ia another factor affecting the number of years of farming .Some farmers have been known to have other jobs other than farming .The farmer respondents indicated that they personally produced their tubers.In most of the LGA studied, however most of the work force seemed to be by hired labour.

4.1.DISTRIBUTION OF TUBERS CULTIVATED

The cropping system in all areas of study is mainly multiple cropping .Multiple cropping in this work is defined as the growing of two or more crops on the same field during the same cropping season .Relay cropping is also sometimes practiced .This is where cassava is planted together with yam .According to wood (1988),relay cropping is when one crop is interplant with a second crop as the first approach maturity .Yam

heaps are constructed in a row while cassava is planted in the space in the space between two in a heap in a row when thee yam is near maturity in rainy season about to three to four months after planting the most common tubers cultivated by these farmers which spread across each LGA of the two states are cassava yam sweet potato and coco yam

Table 3: Percentage Distribution of Crop s grown in each LGA oof Kwara State

LGA	Total no of people Interviewed	cassava	Yam	s.potatoe	Cocoyam	C&y	C&sp	Y&sp	C,y,&sp
Oke-Ero	20	26.03	26.92	8.22	5.48	8.22	10.96	4.11	9.59
Ekiti	16	28.85	34.56	9.62	3.85	5.77	8.62	10.60	5.77
Irepodun	24	34.56	17.17	7.27	-	3.63	12.73	-	7.27
Offa	18	15.15	28	16.16	8.0.	7.07	9.09	11.11	16.16
Oyun	22	18.09	21	15.96	9.57	8.51	8.51	2.19	14.89
Average	20	24.54	25.47	11.46	5.40	6.64	9.98	5.80	10.77

From the table shown above it was discovered that in Offa LGA only 15.15% cultivated cassava, 17.17% cultivated yam 16.16 % cultivated potato, 8.08% cultivated cocoyam ,7.07% cultivated cassava and yam :9.09% cultivated cassava and sweet potato, 11.11% cultivated yam and sweet potatoes and 16.16% cultivated both cassava ,yam and sweet potato.

It was also discovered that yam had the higher percentage number of cultivators .This was closely followed by cassava. Others were discovered to have a low percentage number of farmers cultivating them compared to others.

Table 4 Percentage Distribution of crops grown in each LGA of Benue State

LGA	TOTAL NO OF PEOPLE INTERVIEWED	CASSAVA	YAM	SWEET POTATO	COCOYAM	C&Y	C &SP	Y & SP	C,Y &SP
UKUM	2.2	10.53	55.26	-	-	34.21	-	-	-
KATSINA	18	24.14	44.83	-	-	31.03	-	-	-
GWER	15	24.53	9.43	18.87	3.77	11.32	13.21	11.32	7.55
ADOR	25	14.46	15.56	9.64	18.04	8.43	14.46	10.84	8.43
OKPOKWU	16	21.43.	16.67	11.90	21.43	7.14	4.46	9.52	7.14
VANDEIKYA	24	28.81	18.64	15.25	-	8.47	13.56	5.08	10.17
AVERAGE	20	20.65	20.76	9.28	7.21	16.77	7.67	6.13	5.55

From the table shown above, it was discovered that in Ador LGA, only 14.46 % cultivated cassava, 15.56% cultivated yam, 9.64% cultivated sweet potato ,18.07% cultivated cocoyam, 8.43% cultivated cassava and yam, 14.46% cultivated cassava and sweet potato, 10.84% cultivated yam and sweet potato and, 8.43 % cultivated both cassava, yam and sweet potato

It was also discovered that ,yam had the highest percentage of cultivators .This was closely followed by cassava. Others were discovered to have a low percentage number of farmers cultivating them compared to others .

Fig 2 Percentage distribution of storage structure in kwara state

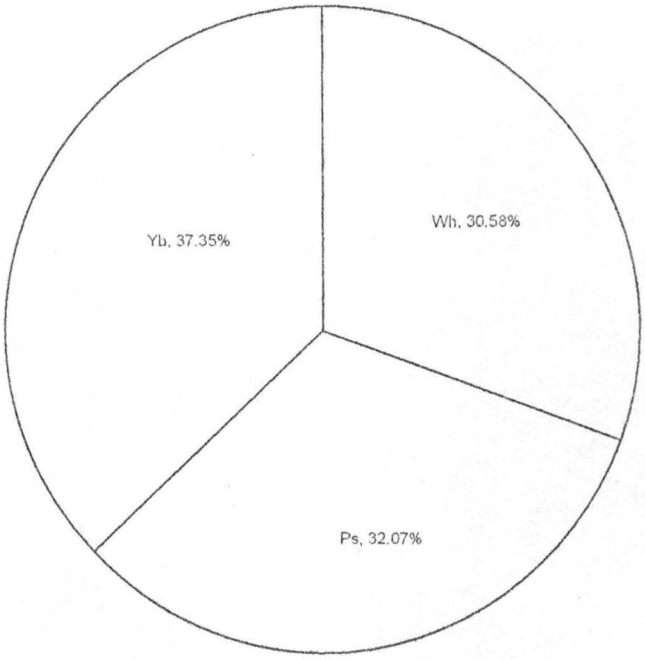


Figure 3 Percentage Distribution of Storage Structure In Benue State

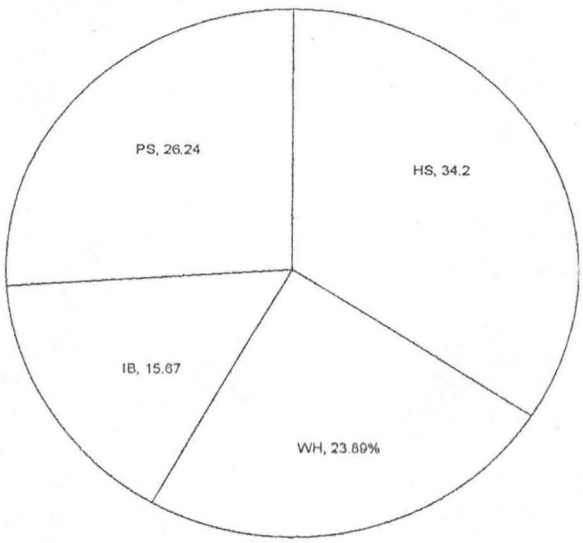


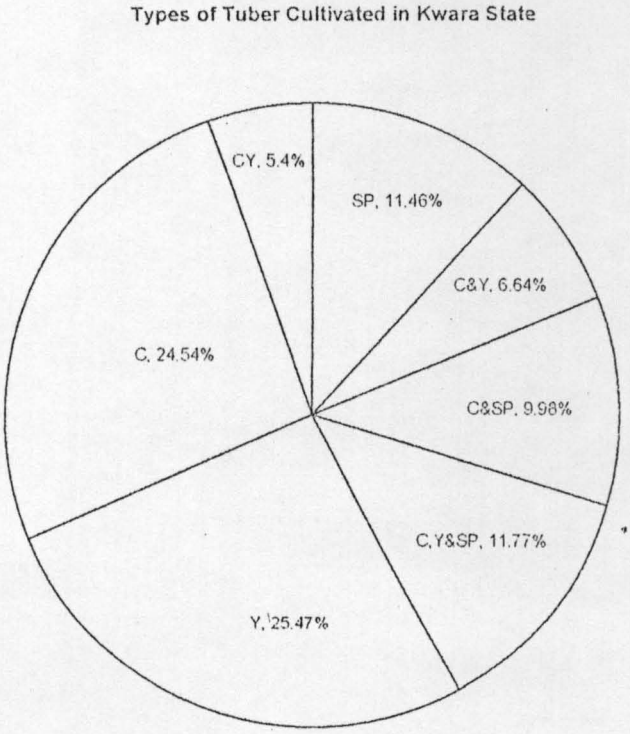
Figure 4 Types of Tuber Cultivated In Kwara State

PS – pit storage

WH – Ware house

YB – Yam Barn

Hs – Hut storage



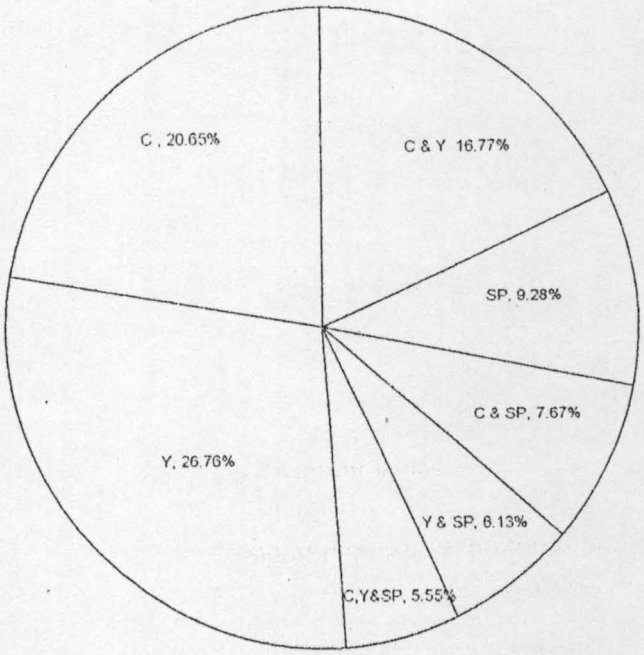
Where c = cassava

Y = yam

Sp = sweet potato

Cy = cocoyam

Fig 5 Types of Tuber Cultivated In Benue State



Where c = cassava

Y = yam

Sp = sweet potato

Cy = cocoyam

Figure 5 Types of Tuber Cultivated in Benue State

4.2 Root and tuber structure in Kwara and Benue

The difference storage structure practiced are pit, ware house, yam barn and hut storage

Table 5 Percentage Distribution of storage Structure and Methods in Kwara State

LGA	PIT STORAGE	WARE HOUSE	YAM BARN
Oke-Ero	22.82	34.64	42.54
Ekiti	37.31	26.48	36.21
Irepodun	29.48	31.22	39.10
Offa	30.30	39.22	30.48
Oyun	32.99	28.58	38.43
Average	30.58	32.07	37.35
standard deviation	8.18	7.68	7.16

Table 6 Percentage Distribution of storage Structure and Methods in Benue State

LGA	Pit Storage	Ware House	Yam Barn	Hut Storage
Zaki – Biam	23.04	19.24	-	57.72
Katsina – Ala	21.10	22.20	-	56.70
Gwer	24.60	35.06	-	40.34
Ador	36.12	20.24	43.64	-
Okpokwu	31.24	18.40	50.36	-
Vandeikya	21.36	28.22	-	50.42
Average	26.24	23.89	15.67	34.20
Standard deviation	12.14	11.95	25.58	27.92

In Kwara State ,it was discovered from the table above that yam barn has the highest percentage of usage, followed by warehouse and pit storage has the least percentage while from the table 6 shown above, it was discovered that hut method of storage has the

average percentage of usage followed by pit storage ,warehouse and yam barn has the least percentage in Benue state.

4.3 DISTRIBUTION OF STORAGE FACILITIES FOR STORING PRODUCE

Putting fresh roots and tubers into processed produce would prolong their self life than in fresh form .Fresh tubers that will be produced should be processed immediately after harvest to reduce contamination by insects and micro organism as this would affect the quality and storability of the finished product. The storability of processed products is largely dependent on how tubers are before processing and how long they have being in fresh form before the choice of processing .Most often the fresh tubers are processed into cassava chips ,Gari ,flour, and sweet potato chips .These products can be stored well using sacks pots, calabash , plastics and drums depending on the quantity if properly dried before storage

Table 7 Percentage Storage facilities for storing processed produce in Benue state

Processed	Sacks	Pots	Calabash	Plastics	Drums
Chips	15.60	16.70	22.20	29.90	16.70
Flour	24.40	15.60	20.00	21.10	18.90
Gari	51.00	-	-	49.00	-
Average	30.33	10.11	14.07	33.33	11.87

Table 8 Percentage Storage Produce Facilities For Storing Processed Produce In Kwara State

Processed	Sacks	Pots	Drums
Chips	55.56	37.04	7.40
Flour	61.22	30.61	8.17
Gari	90.91	9.09	-
Average	69.23	25.58	5.19

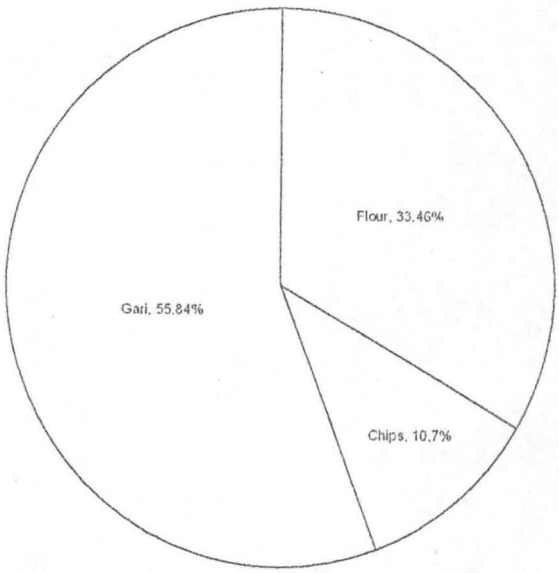


Figure 6 Percentage of Root and Tuber Processed produce in Kwara Stae

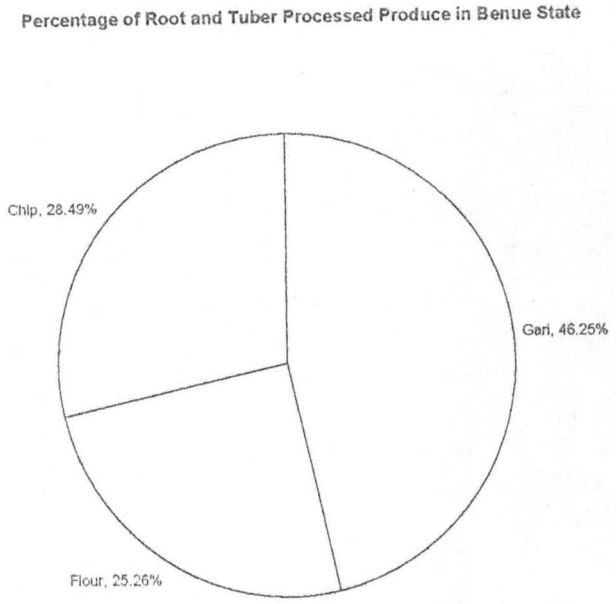


Figure 7 Percentage of Tuber and Processed Produce in Benue State

In figure 6 above, Gari production takes the highest percentage followed by flour while the least percentage is chips in production.The production in each case might be attributed to the availability of sun energy which are readily available for drying .In figure 7 above Gari production also takes the highest in percentage followed by chips and while flour has the lowest percentage .

From figure 8 below the use of sacks as indicated has the highest percentage of 69.23% while the pots and drums took the lowest percentage of 25.58% and 5.19% respectively .Reading from figure 9 below, the use of plastics and sacks is predominant in the state of Benue with a high percentage of 33.33% and 30.33% respectively .

The use of calabash, drums and pots had the least percentage in the state .It was gathered that drum are made relatively airtight by tightening a clamp to hold the lid into the drum ,Fumigants are usually required to reduce the incidence of infestation .Pots and

drums were mainly used among the small scale farmers in both states while the large scale make use of sacks for the storage of their processed produce.

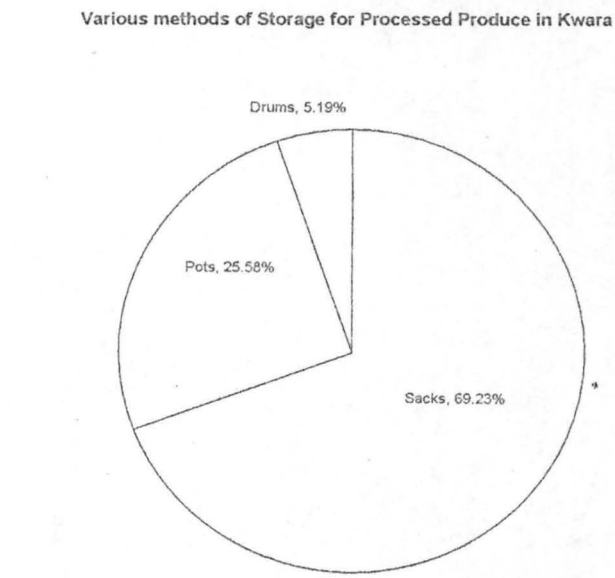


Figure 8 various methods of Storage for Processed Produce in Kwara State

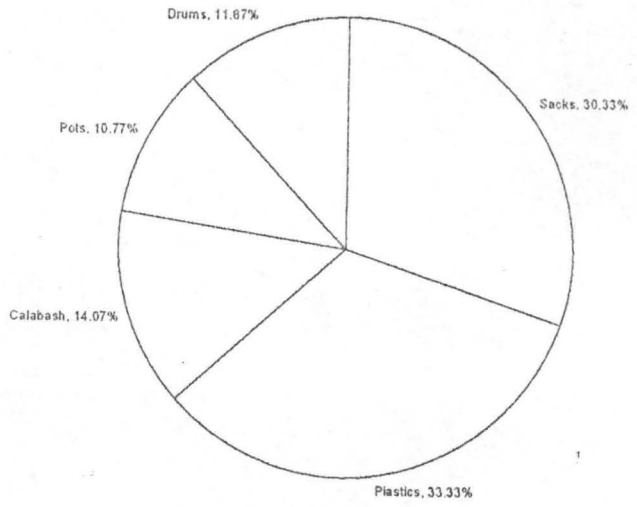


Figure 9 Various methods of Storage for Processed Produce in Benue State

4.4. PROBLEM ENCOUNTERED IN STORING PROCESSED PRODUCE

It was discovered that the storability of processed products is largely dependant on how fresh tubers are before processing .The most processed tubers are cassva ,yam and sometimes sweet potato .The deterioration in processing produce are fungal damage infection ,rodent attack, cockroach attack, thieves and mechanical damage

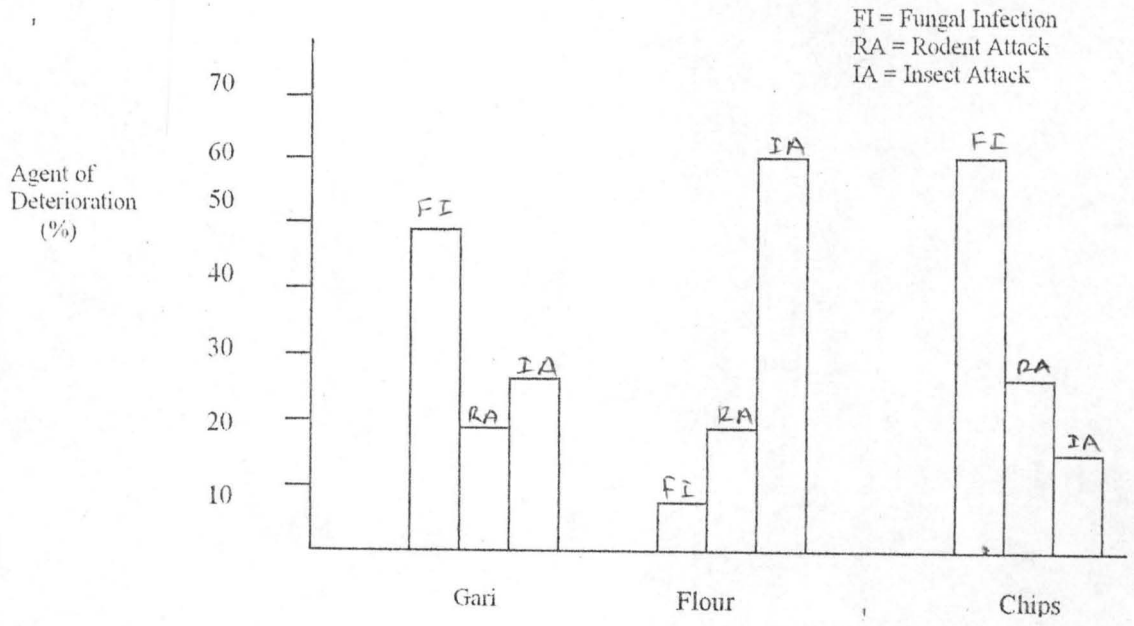


Figure 10 Percentage Agent of deterioration in processed produce in Kwara state

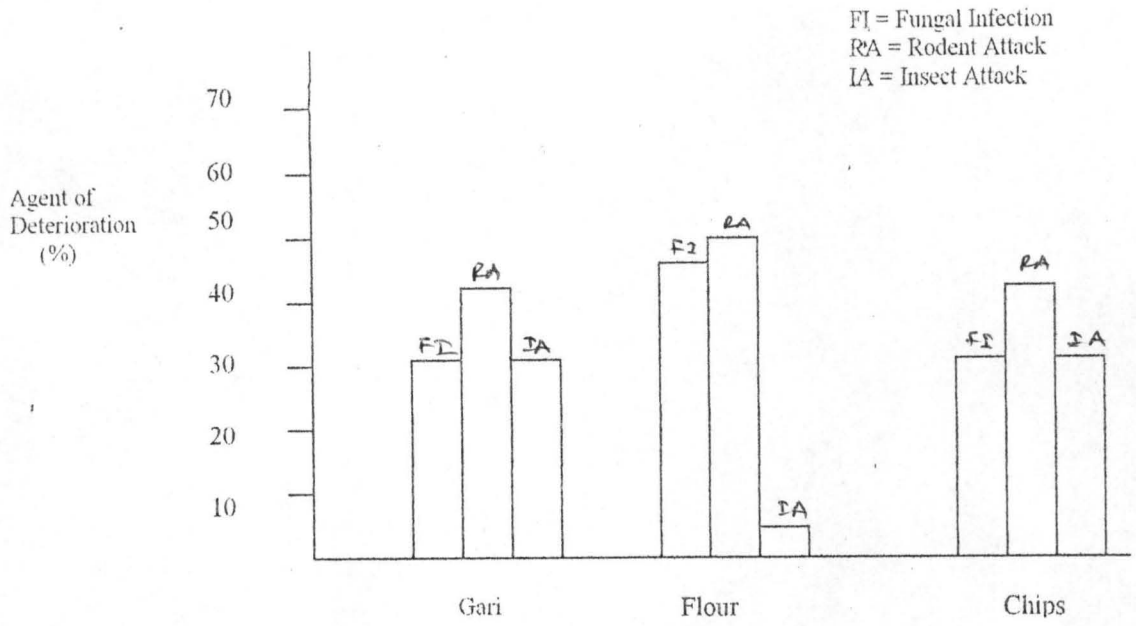


Figure11 Percentage deterioration in processed produce in Benue

4.5 Various Losses in Roots And Tuber Crops In Each LGA

Table 9 losses through various agents of deterioration in Kwara state

LGA	Rodents	Insects	Mould/Rotting	Thieves	Mechanical Damage
Oke –Ero	25.92	22.15	25.95	14.56	11.42
Ekiti	14.38	16.38	33.75	25.92	9.57
Irepodun	26.86	24.37	16.17	16.42	16.18
Offa	25.43	25.23	23.00	12.76	13.58
Oyun	24.75	23.43	21.23	14.64	15.95
Average	23.47	22.31	24.02	16.87	13.34

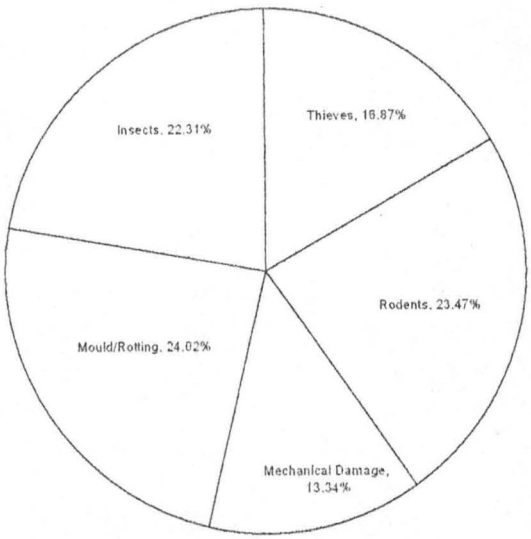


Figure 12 percentage losses through various agents of deterioration in Kwara state agents

From the table 9 it indicate that rodents, insects and mould/rotting are the major agents of losses destroying stored tuber crops in Oke –Ero ,Offa and Oyun LGA while their least percentage are thieves and mechanical damage .When compared generally throughout the LGA the highest percentage are also the rodents ,insects and mould/rotting with 23.47% ,22.31% and 24.02% respectively.

Table 10 Various losses through agents of deterioration in Benue state

LGA	Rodents	Insects	Mould/Rotting	Thieves	Mechanical Damage
Ukum	26.70	21.20	24.80	15.42	11.88
Katsina – Ala	15.43	15.25	32.70	26.73	9.89
Gwer	24.72	22.40	15.85	17.52	19.51
Ador	25.36	21.24	22.52	7.89	22.99
Okpokwu	23.83	22.42	22.20	15.53	16.02
Vandeikya	23.40	21.27	23.33	16.98	15.02
Average	23.24	20.63	23.57	16.68	15.89

From the table shown above it was discovered that in Ador LGA thye least percentage of all is thieves with 7.89% while the other has the highest i.e rodents ,insects mould/rotting and mechanical damage .The result of six LGA showed slightly the same while the highest percentage is attributed to rodents ,insects and mould/rotting.

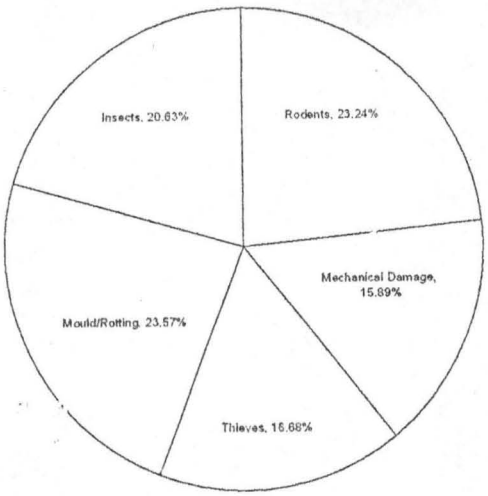


Figure 13 Percentage Losses Through Various Agents Of Deterioration In Benue State.

4.6 Estimated Quantity Of Tubers Produced Annually In Each LGA (Tuber '000)

It was gathered that farmers in Kwara and Benue states cultivated above two hectare of land as maximum and less than one hectare as minium.from the interviewer the season of planting cassava mostly is in the month of June and July from both states .Yams are planted two times in a year i.e April and November period .Sweet potato are planted in June and July for Benue state and Kwara state respectively. Cocoyam is planted in May period.

The period of harvesting each tuber also differ because tuber utilization distribution is entirely the perrogative of whoever owns the tubers .In Benue state, cassava is harvested in November ,September ,August and December (descending order).Sweet potato is harvested in October mostly in Kwara and Benue state respectively.

Table 11 Estimated Quantities of Tubers Produced per Person in each LGA of Kwara State in Tonnes.

LGA	Cassava	Yam	Sweet – Potato	Cocoyam
Oke – Ero	9.09	19.09	3.40	0.36
Ekiti	4.12	11.33	2.90	0.23
Irepodun	4.73	12.82	1.25	0.31
Offa	2.76	9.89	4.33	0.69
Oyun	4.97	8.13	3.85	0.27
Average	5.13	2.25	3.15	0.37

Table 12 Estimated Quantity of Tubers Produced per Person in each LGA of Benue State in Tonnes.

LGA	Cassava	Yam	Sweet Potato	Cocoyam
Ukum	5.61	20.26	-	-
Katsina-Ala	2.99	18.06	-	-
Gwer	7.51	13.45	0.54	0.63
Ador	3.79	6.08	0.61	0.35
Okpokwu	5.30	8.64	1.06	0.30
Vandeikya	9.12	4.41	0.49	0.48
Average	5.72	11.82	0.46	0.29

Table 13 Estimated Production of Tuber crops per States in Tonnes

States	Total Population	Total Agric. Population	Production (10^6) in tones			
			Cassava	Yam	Sweet Potato	Cocoyam
Kwara	1,548,412	136,104	0.70	1.67	0.43	0.05
Benue	2,753,077	1,741,011	9.96	20.58	0.80	0.51

OBSERVATION

It was observed that tuber utilization distribution is entirely the prerogative of whoever owns the tubers ,he could decide to sell off everything or store everything or process some of it or have a combination of the three alternatives .The degree to which each of these is achieved depends on the yield of the farmers for that particular season .At time when yield is quite small the farmer could sell off everything and leave just a handful for the next planting season or store them for his family consumption or process everything depending on the tuber or what plans he /she had in mind as regards the tubers.

In all LGA visited, it was observed that for yams a greater percentage of the respondents sold more of the tubers followed by those that stored them and fewer people process the tubers into other produce like yam chips and cassava flour and gari respectively .What I obtained is that they sell off the tubers and the people that buy them process them into other produce mostly gari and store the processed produce.

4.7 Effective Storage Duration Of Processed Produce

Within the LGA visited they gave an information based on the questionnaires distributed on their effective storage duration .For example in Ador LGA most farmers interviewed said that they stored cassava processed in plastics and sacks between 4 to 8 months while that of yam process produce are between 2 to 4 months.In Gwer LGA a food

stuff trader said that the length of the storage of yam used to prepare the flour i.e. water yam cannot be used .She added that some species of yam had tendency of absorbing moisture content from the surrounding than others and this make their storage life to be shorter than others .She pointed out also that regular disposal of stock and prevailing environmental condition contribute to good quality storage of tuber processed produce .yam and cocoyam in Okpokwu LGA can be stored along side with at least five and three months respectively Some species types of storage structures were found and used in specific LGA which depends mainly on the geographical location.

The simple random sampling technique was employed in the administration of the questionnaire .The method used to collect information such as type of tuber cultivated ,storage methods causes of spoilage,amount of tuber grown,amount of tuber process and source of loss .During the administration of the questionnaire an intermittent sample space was adopted to ensure that the information received without preference .Most of the farmers interviewed plants more than one tuber crop. Types of tuber cultivated depend on the interest of the farmer in the production .Most set of farmers in Ukum LGA does not show any interest in cultivation of sweet potato and cocoyam but focused majorly on yam followed by cassava production .Some of the farmers in Oke – Ero LGA, particularly Odo – Owa ,cultivated tuber crops for sales and to feed their family while few cultivate in order for sales and to process greater percentage of harvest products .

The harvested tuber are carefully selected and sorted out after harvesting for sales or storage .At times yield is quite small the farmer could sell off everything and leave just an handful for the next plant season or store them for his family consumption or process depending on the tuber and what plans .he/she had in mind as regards it .In all the LGA

visited however, there are more process produce in term of cassava to yam because it be process into different forms more than others..It was very difficult to identified sweet potato processed produce especially during the harvest season.

The harvest could either be single or double (yam) the double harvest is divided into first and second period as the case may be .The first harvest take place about four to six months after emergence of the plants .The tubers are carefully uncovered and separated from the plant without damaging it after the harvest ,the bed which has been dug is re – prepared .The pant react to this interference with increase production of tuber tissue so that a second harvest can take place after wilting point. The double harvest have a pronouncedplanting features and less suitable for eating .This high work input of the process of double harvesting is mainly from the first harvest are available early from consumption.

They are also highly estimated and attain corresponding in high price in the market .The double harvest is a process with a very high input of labour .Mechanization is very difficult here which means work relief through the use of technical process is hardly possible.

Rodent attack can be controlled by good storage hygiene and conventional control measures .by storing the raw tubers and process produce of it in a warehouse ,rodents attacks cannot be eliminated except in the modified storage houses .The following steps should be taken:-

1. Provision of raised platform which is to prevent the moisture form the ground
2. Adequate protection against rodent and insects proliferation i.e fumigants should be applied before storage.
3. The house should be cleaned so that agent of deterioration may be eliminated.

4. Both major and minor repairs on the house should be properly carried out before storage.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The quantity of root tuber crops lost in each local government area varies .Most often with the quantity harvested to storage structures which are not too efficient and the various sources of loss inherent in these structures .The problem actually starts from harvesting where most of the roots and tubers are bruised and damaged thereby predisposing them to high rate of microbial - infestation resulting in rot during storage .Roots and tubers are bulky making them difficult to handle and contain high moisture content .

The damage to the tubers also continues throughout handling transportation and storage .During storage ,condition must be such that the tuber does not have rot respire excessively or lose its food reserves .It is hoped that this research work will be made available for further research on study of tuber storage structures and method in other parts of the state.

This piece of work is hope at arousing awareness of the importance of tuber storage in mans constant effort to obtain his primary need. That is the supply of good quality food for the country at large and himself at a reasonable price without undue wastage.

5.2 RECOMMENDATION

In conducting a research work of this project the researchers should first determine the number of villages to be covered in each local government area of state and where possible , for accurate result,study should commence immediately after the harvest.

It is important that farmers should inculcate good maintenance culture of their various storage structures.This is achieved by a thorough cleaning of the store to remove all traces of previous tubers stored .The roots and tubers to be stored should be to a safe moisture content and condition closely monitored during storage.

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APPENDIX A

QUESTIONAIRE

RESEARCH TITLE : EVALUATION OF THE VARIOUS STORAGE STRUCTURES AND METHODS IN MIDDLE BELT OF NIGERIA (KWARA AND BENUE STATE)

RESEARCHER: KEHINDE SAMUEL OLADELE

DEPARTMENT OF AGRICULTURAL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

Dear respondents

Across the world today agriculture is the major source of food supply for the survival of man and animals .I realize that all efforts to improve the rate of food production have been hampered due to the problem of storage structures and methods.

The various agricultural sectors in the country have tried to remove this problem but not much impact have been made in order to create more impact this questionnaire that references will be drawn on the possible solution to those problems·It will be appreciated if few moments are spared to answer the following questions as accurately and as correctly as· possible·please be sure that your response will be treated in confidence

Thanks for your cooperation.

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

DEPARTMENT OF AGRICULTURAL ENGINEERING

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ur Ref:

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P. M.B. 65, Minna.

18th March, 2004.

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Dear Sir/Madam,

LETTER OF INTRODUCTION.

The bearer KEHINDE SAMUEL OLADELE with Registration Number 98/7031EA is a final year Agricultural Engineering Student of our University.

We will appreciate your kind assistance in providing him with relevant information and access to your facilities to enable him carry out his final project successfully.

Thank you.

18.03.04

Engr. Dr. D. Adgidzi
Head of Department
Agric. Engineering Department.

1. GENERAL VIEW

I. Name:.....

II. Sex:.....

III. Age:.....

IV. Town/Village where farm is located:.....

V. No. of Houses:.....

VI. Marital Status:.....

VII. Educational Qualification:.....Tick ☐

Primary ☐ Secondary ☐ Above Secondary ☐ None ☐

VIII. MAJOR OCCUPATION: Tick ☐

Farming ☐ Fishing ☐ Hunting ☐ Handcraft ☐ Trading ☐

IX. Type ownership: Tick Private ☐ Government ☐

TUBER PRODUCTION

I. No of hectare cultivated : Tick 1Ha ☐ 2Ha ☐ 3Ha ☐

II. Major tuber predominantly cultivated in your area

Tick Cassava ☐ Yam ☐ Sweet potato ☐ Cocoyam ☐

III TIME OF PLANTING AND HARVESTING

	Time Of Planting	Time Of Harvesting
Cassava		
Yam		
Sweet Potato		
Cocoyam		

IV QUANTITY OF TUBER WHICH YOU PRODUCED

	Quantity
Cassava	
Yam	
Sweet Potato	
Cocoyam	

V DO YOU NORMALLY HARVEST ALL THE TUBERS AT ONCE TICK ☐

YES ☐ NO ☐

VI HOW LONG DO YOU NORMALLY LEAVE THEM UHDER THE GROUND

TICK YES NO

☐ ☐ ☐

VII MAJOR COMMODITY WHICH YOU MARKET TICK ☐

CASSAVA YAM SWEET POTATO COCOYAM

☐ ☐ ☐ ☐

VIII QUANTITY MARKETED

	Quantity Marketed
Cassava	
Yam	
Sweet Potato	
Cocoyam	

3 TUBER STORAGE METHOD

I LOCATION OF STORAGE TICK ☐ HOME ☐ FARM ☐ BOTH ☐

II AMOUNT / QUANTITY OF TUBER STORED (%)

	Quantity Stored (%)
Cassava	
Yam	
Sweet Potato	
Cocoyam	

III TYPE OF STORAGE TICK BARN ☐ WAREHOUSE ☐ HUT ☐ PIT ☐

IV DURATION OF STORAGE TICK 6 MONTHS ☐ 2-4 MONTHS ☐ <4 MONTHS ☐

V AMOUNT CONSUMED IMMEDIATELY (%)

	Amount (%)
Cassava	
Yam	
Sweet Potato	
Cocoyam	

VI CHANGE NOTICED AFTER STORAGE

	Change In Colour	Change In Smell	Change In Taste	Moulding And Rotting
Cassava				
Yam				
Potato				
Cocoyam				

VII DO YOU MAINTAIN THE EXISTING STORAGE STRUCTURE

TICK YES NO

☐ ☐ ☐

VIII IF YES PLEASE SPECIFY WITH COST N

IX IF NO HOW OFTEN DO BUILD TICK ☐

ANNUALLY ☐ BI- ANNUALLY ☐ TRI – ANNUALLY ☐

X DO YOU APPLY CHEMICALS TO STORAGE STRUCTURE

TICK	YES	NO
☐	☐	☐

XII QUANTITY OF TUBER LOST /DAMAGED PER METHOD OF STORAGE

	% Lost Damaged
Cassava	
Yam	
Sweet Potato	
Cocoyam	

XIII NATURE & QUANTITY OF DAMAGED DUE TO AGENTS OF STORAGE

(%)

	Insects	Rodents	Fire	Rotting
Cassava				
Yam				
Sweet Potato				
Cocoyam				

4 METHOD OF PROCESSING

I METHOD USED TICK

	MACHINE	LOCAL
Cassava	☐	☐
Yam	☐	☐
Sweet Potato	☐	☐
Cocoyam	☐	☐

II METHOD OF PRSERVATION EMPLOYED /USED.....

III INTO WHAT PRODUCTS DO YOU PROCESS

CHIPS	FLOUR	ANY OTHER

IV AMOUNT PROCESSED

	Amount (%)
Cassava	
Yam	
Sweet Potato	
Cocoyam	

V HOW IS THE FINISHED PRODUCT STORED? TICK ☐

POTS ☐ DRUMS ☐ PLASTICS ☐ SACKS ☐

VI HOW LONG IS THE FINISHED PRODUCT STORED ? TICK ☐

< 1 MONTH ☐ 2- 3 MONTHS ☐ . 3 MONTHS ☐

VII USES OF THIS TUBER TICK ☐

S/N	Human Consumption	Animal Consumption	Selling	Industrial Usage	Export	Others
1						
2						
3						

VIII WHAT TYPES OF PROBLEM ENCOUNTERED IN STORING PROCESSED PRODUCT

IX QUANTITY LOST DURING PROCESSED PRODUT STORAGE (%)

NAME OF STORAGE STRUCTURE	NAME OF TUBER STORED	LIFE SPAN OF STRUCTURE (YEAR)	NUMBER OF STRUCTURES	EFFECT OF RAINFALL HIGH/LOW/MED	CAPACITY OF STRUCTURE	DURATION OF TUBERS STORED	MATERIALS USED FOR CONSTRUCTION	COST OF CONSTUCTION
PIT								
BARNS								
WAREHOUSE								
HUT								
OTHERS SPECIFY								

APPENDIX B

NUTRITIONAL COMPOSITION OF ROOT TUBERS ON FRESH WEIGHT BASIS

	YAM D.Alata	CASSAVA D.Esculanta	SWEET POTATO	TANNIA COCOYAM
MOISTURE (%)	77.3	62.8	71.1	67.1
ENERGY (Kj/100g)	347.0	580.0	438.0	521.0
PROTEIN (%)	2.2	0.5	1.4	1.6
STARCH (%)	16.7	31.0	20.1	27.6
SUGAR (%)	10.0	0.8	2.4	0.4
FAT (%)	0.1	0.2	0.2	0.1
ASH (%)	0.8	0.8	0.7	1.1